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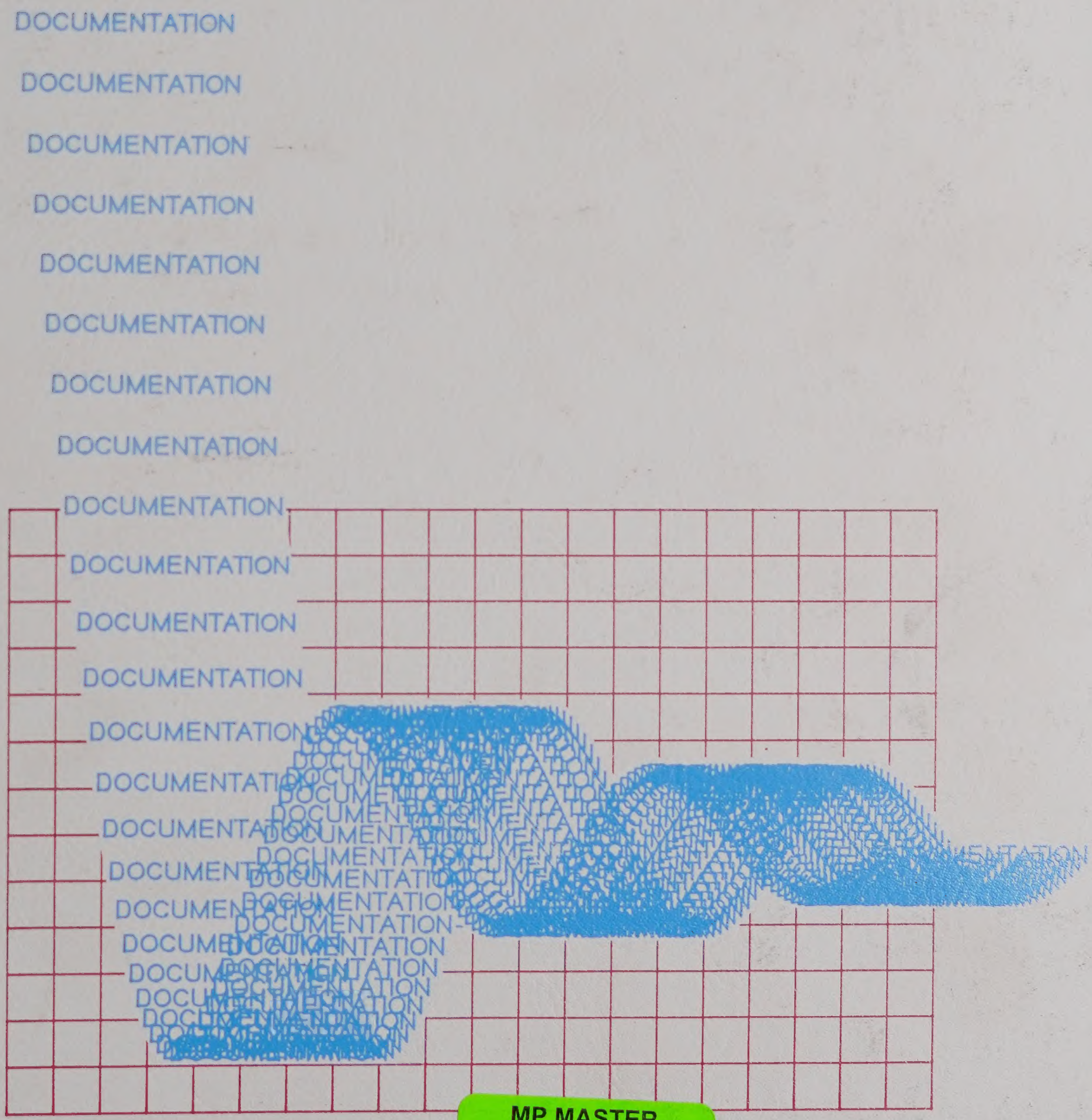

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Software Manual

Software WinIQSIM for Calculating I/Q Signals for Modulation Generator AMIQ

WinIQSIM

1013.1642.02

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I/Q Modulation Generator AMIQ

- 14 bit resolution
- 4 000 000/16 000 000 sample memory depth
- 100 MHz sample rate
- 78 dB ACP dynamic range (typical of 3GPP FDD)
- Integrated hard disk and floppy disk drive
- Optional BER measurement (AMIQ-B1)
- Optional differential I/Q outputs (AMIQ-B2)
- Optional digital I/Q output (AMIQ-B3)

ROHDE & SCHWARZ

The ultimate in I/Q signals

- 100 MHz clock rate per channel
- Up to 16000000 samples per channel
- Generation of broadband digital communication signals (e.g. WCDMA, HiperLAN2 and IEEE802.11a)
- Built-in hard disk for storage of calculated signals
- Downloading of calculated waveforms and signals also from integrated floppy disk drive
- Antialiasing filter featuring excellent frequency response and group delay
- Auto-alignment and additional user correction of amplitude and offset
- Fine adjustment of I/Q skew
- Wide dynamic range through the use of 14-bit D/A converter, ideal for multicarrier applications
- Excellent ACP (adjacent-channel power) values with WCDMA 3GPP FDD signals of typically –78 dBc for test model 1 with 64 channels

The number of systems based on complex digital modulation methods has dramatically increased in every field of communications. I/Q modulation is therefore gaining importance for the development of such modulation methods. The Modulation Generator AMIQ and the Simulation Software WinIQSIM™, which is described in a separate data sheet (PD 0757.6940), open up new dimensions for the generation of I/Q signals.

The AMIQ is a dual-channel modulation generator that has especially been designed for use as an I/Q source. It is programmed and set with WinIQSIM™. Alternatively, the AMIQ can be operated from the Vector Signal Generator SMIQ.

Of course, the AMIQ features full remote-control capabilities via the GPIB/IEEE and RS-232-C interfaces.

Each channel can store up to 16 000000 samples. Sequences of sufficient length can thus be generated even at high symbol rates. Featuring clock frequencies of up to 100 Msample/s and a high amplitude resolution of 14 bit at the analog signal output and up to 16 bit at the digital signal output, the AMIQ is the ideal source for any digital modulation signal.

An automatic amplitude/offset alignment as well as fine adjustment of the skew provide excellent symmetry of the two channels which previously was extremely difficult to attain with dual-channel ARB generators. The error vector is thus minimized.

The filters have been optimized regarding group delay, frequency response and matching between the two channels for use as an I/Q modulation source.

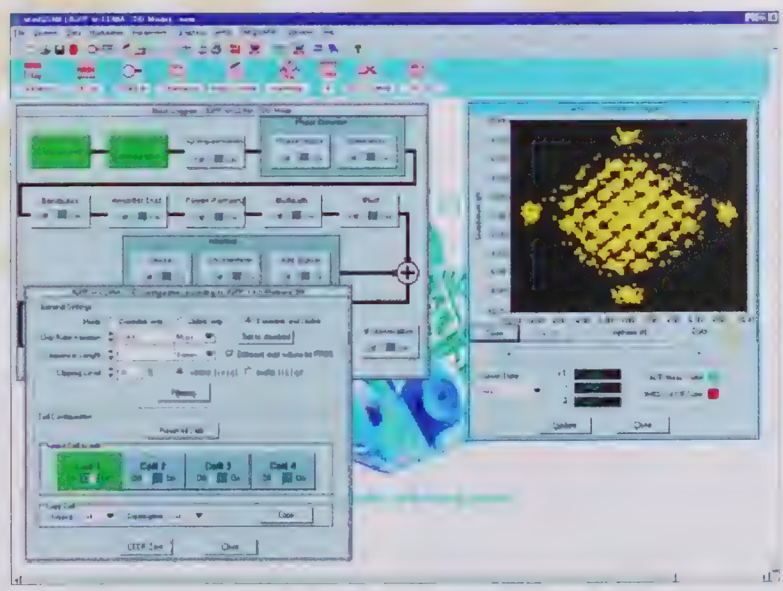
Typical applications of the AMIQ and WinIQSIM™ not only include driving the I/Q inputs of a vector signal generator; the combination is also ideal for direct applications in the baseband, such as testing I/Q modulators/demodulators.

The digital signal output (option AMIQ-B3) opens up further applications in the baseband: digital/analog converters (DACs) or digital input base stations can be tested, for example.

- Single-carrier signals
- Multicarrier signals (up to 512 modulated or unmodulated carriers)
- Multicarrier mixed signals (up to [illegible] modulated carriers)
- [illegible] CDMA signal [illegible]
- [illegible] impairments
- [illegible] for creating any TDMA [illegible]
- [illegible] for TDMA mobile [illegible] GSM, GSM EDGE, [illegible] IS136), PDC, [illegible] 1 to 4 for WCDMA [illegible]
- [illegible] calculated sig[illegible] diagram, vector [illegible] magnitude and [illegible] spectrum, etc) [illegible] the AMIQ
- [illegible] allows data [illegible] programs to [illegible] TCP/IP and DDE [illegible]

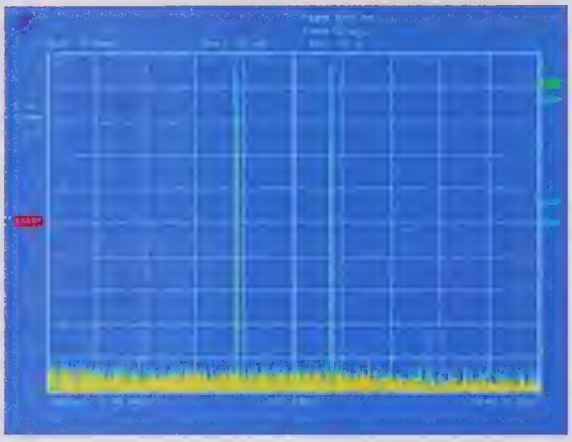
WinIQSIM™ is a Windows software program for calculating I and Q baseband signals. Its functionality ranges from single-carrier modulation, generation of multicarrier, CDMA and WCDMA signals through to TDMA frame configuration with the help of a convenient data editor All modulation parameters and impairments can be simulated for single-carrier, multicarrier as well as for CDMA signals To put it in a nutshell: WinIQSIM™ is an indispensable tool for anyone engaged in modern digital modulation

This Windows software enables the AMIQ to simply generate complex modulation signals. This includes modulation signals for WCDMA 3GPP, which is similar to QPSK, or 8PSK EDGE modulation with 3π/8 shifting for the EDGE enhancement in the GSM standard. OFDM, which is used for HIPERLAN/2, and where a data stream is transferred via a large number of carriers, is a special modulation format For generating this type of signal, the WinIQOFDM software (see www.rohde-schwarz.com) is used



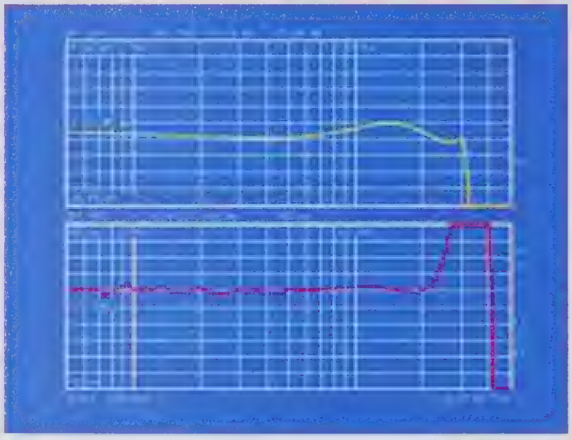
One modulation generator ...

In addition to the great memory depth of up to 16 000 000 samples, the AMIQ is outstanding especially for its wide dynamic range and excellent spectral purity. For WCDMA signals, low adjacent-channel power (ACP) in the baseband is thus ensured. The built-in filters are designed for flat frequency response and constant group delay.



Intermodulation characteristic of the AMIQ at 50 MHz clock rate

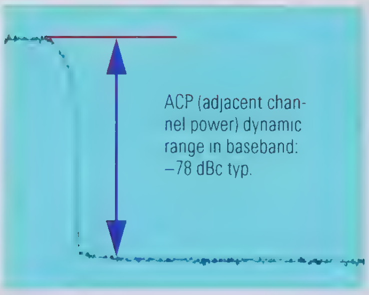
For an I/Q source, it is especially important for the two channels to be identical since any difference would inevitably cause an additional modulation error.



Frequency response and group delay of 25 MHz output filter

Automatic internal alignment of offset and amplitude of the I and Q channels guarantees high performance. Small amplitude or offset errors of the connected device under test can be user-corrected for overall system alignment. This user correction is independent of the automatic internal alignment.

Skews between the I and Q channels, which may be caused, for example, by slight differences in the connecting cables between the AMIQ and the vector signal generator, can be compensated with a resolution of approx. 10 ps.



All these features are the basis for the outstanding modulation performance of the AMIQ.

The signal output can be externally controlled. The clock rate of the I/Q output can be adapted to the device under test by means of an external clock. Four user-programmable marker outputs can be synchronized to the desired sample and used, for example, to generate sync pulses at the beginning of a timeslot or to drive the power ramping input of an RF signal generator.

Measuring the bit error rate has become a frequently used method for the verification of digital communication systems (e.g. measuring the sensitivity or selectivity of receivers, subsystems and components). The **option AMIQ-B1** allows the AMIQ to be used for BER (bit error rate) measurements. The device under test (DUT) must deliver the data to be tested and the associated clock. If the DUT does not have its own clock, the clock can be generated by the AMIQ and output via one of the four user-programmable marker channels. The built-in BER tester compares the data with the nominal data

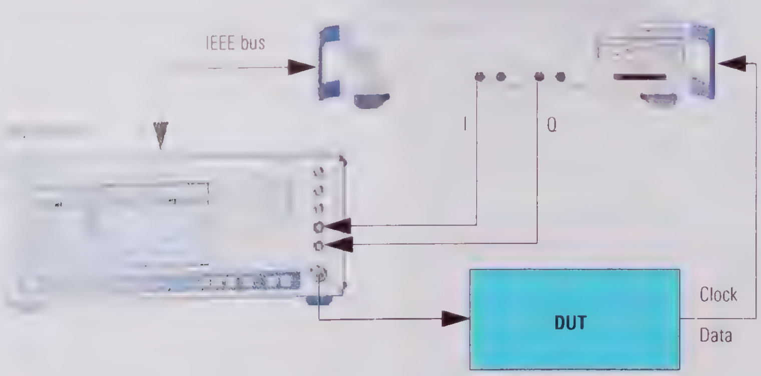
... satisfying all requirements

and calculates the bit error rate. The result of the BER measurement is available via the remote-control interface. Various standard PRBS sequences (PN9, PN15, etc) are used as nominal data.

The BER measurement has an integrating function, i.e. at the wrap-around point of a PRBS sequence the bit error measurement is stopped and restarted by a control signal at the restart input without the previous result being cleared. All partial results are added until the predefined total number of data bits or error bits is attained. Irrelevant data sequences (e.g. preambles) are blanked, if necessary, by means of the control signal at the data enable input so that they do not invalidate the BER measurement. The PRBS sequence and the two control signals (at the marker outputs of the AMIQ) are generated by means of WinIQSIM™

The **option AMIQ-B2** enhances the existing I and Q outputs by providing the inverted $\overline{I}$ and $\overline{Q}$ signal outputs

Example of bit error rate test



To meet all requirements, the option AMIQ-B2 allows a DC (bias) voltage to be superimposed on the balanced modulation signal (e.g. for setting the operating point). This bias voltage can be set separately for the I and Q channels with high resolution.

Using the AMIQ-B2, unbalanced signals can be converted to balanced signals without requiring an external circuit

The **option AMIQ-B3** provides the digital I and Q waveform data for each channel at a 68-pin SCSI connector on the front panel. A resolution from 8 bits to 16 bits can be selected for the output signals. So it is possible, for example, to drive digital/analog converters (DACs) with different word lengths. By matching the word length, clock and level of the output data to the requirements of the DUT, the AMIQ provides TTL-similar digital signals that are optimally suited for testing digital modules.

The AMIQ considerably enhances the variety of applications of a vector signal generator. It takes over where the internal modulation capabilities of a vector signal generator reach their limits. For example, signals can be generated with a bit rate higher than that which can be processed by the internal modulation coder of an RF generator. The variation capability of any modulation parameter including the superposition of impairments and the generation of IF signals with the aid of WinIQSIM™ is far beyond the facilities of a conventional signal generator. IQWizard[1] allows the conversion of existing signal data that was generated with the aid of mathematical programs, for example.

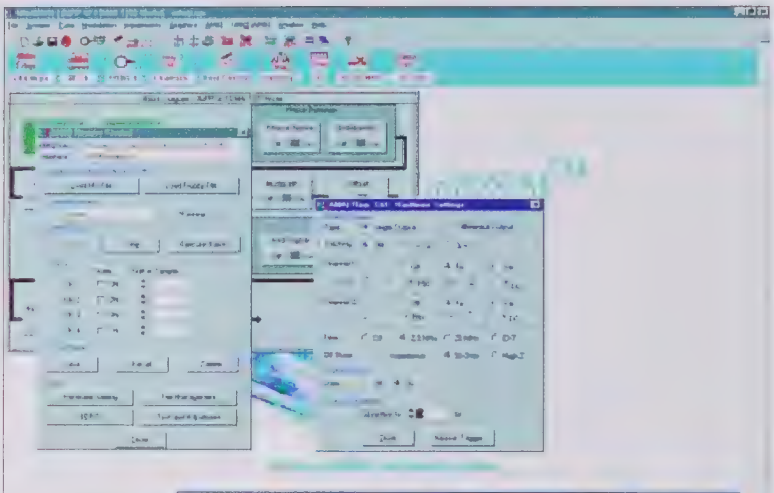
For use in production environments, measuring instruments have to satisfy versatile requirements. One of the main points of interest is the space they require. Since the AMIQ has no built-in display, it is low in height which makes it especially suited for rackmounting in ATE (Automatic Test Equipment) systems. The AMIQ and WinIQSIM™ were designed for high-speed remote control via the IEC/IEEE bus. Predefined signals can be stored on the internal hard disk and quickly downloaded into the output memory.

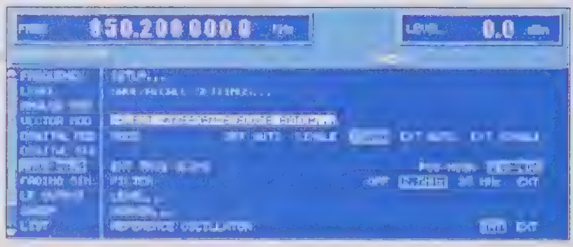
Another benefit of the AMIQ is its 3-year calibration interval: it reduces costs and increases availability.

[1] Can be downloaded from www.rohde-schwarz.com (Application Note 1MA28)

Operation

User interface for controlling the AMIQ with WinIQSIM™





Menu for controlling the AMIQ with the SMIQ

The AMIQ is a black box without any control and display elements. There are several choices for operating the AMIQ:

Operation via WinIQSIM™
With WinIQSIM™, calculated signals are downloaded to the AMIQ hard disk or directly into the RAM of the AMIQ via IEC/IEEE bus or RS-232-C interface. In addition, all AMIQ functions can be set in a menu under WinIQSIM™.

Operation from SMIQ
A PC with WinIQSIM™ is only required if new waveforms are to be calculated, since the once calculated signals can be stored on the hard disk of the AMIQ. In conjunction with the Vector Signal Generator SMIQ from Rohde & Schwarz, it is possible to select waveforms stored on hard disk or floppy and change the AMIQ parameters via a special menu. In this mode, the AMIQ acts as if it were an option to the SMIQ.

Operation in ATE systems
As with any other remotely controlled instrument, all functions of the AMIQ, e.g. downloading predefined waveforms from the integrated hard disk, can be controlled via the remote-control interface. In this operating mode, neither WinIQSIM™ nor an SMIQ is required.

Flexible generation of digitally modulated signals with the AMIQ and the SMIQ

Applications

Verification/conformance testing

For the verification and conformance testing of mobile phones and base stations, signal generators are used for testing subsystems such as receivers, modulators and amplifiers. Due to its versatility and signal quality, the AMIQ is the ideal baseband source to handle these tasks. Preprogrammed standard settings in WinIQSIM™ provides frame structures for all primary mobile radio standards. Thus, it is not only possible to generate signals to standards such as GSM and IS-95, but also to the new WCDMA standards such as 3GPP FDD and TDD, TD-SCDMA and CDMA2000. For some of these standards, a special option is required for output of the signals by the AMIQ.

Development of new communication systems

The comprehensive setting facilities provided in WinIQSIM™ allow future systems to be developed with the AMIQ. The programmable data generator contributes to the easy definition of new TDMA (time division multiple access) systems.

Use of the additional WinIQOFDM software provides the AMIQ with the capability of generating OFDM (orthogonal frequency division multiplexing) signals such as HIPERLAN/2 and IEEE802.11a.

Use in automatic test equipment (ATE) systems

In test systems, space is usually limited. Due to its low height, the AMIQ is an ideal choice for use as a baseband or IF signal source. For this application, the AMIQ certainly benefits from its black box design with an IEC/IEEE bus optimized for high transfer rate, and the integrated hard disk for saving the calculated signals.

In addition to size, the time required is also a crucial factor in ATE systems. Fast switchover between different signal sequences is a very important aspect. The AMIQ provides the possibility of combining up to 30 different sequences with fast switchover. The resulting multisegment waveforms can be stored on the internal hard disk like individual sequences and reloaded into the memory for output.

Tolerance tests

In addition to ideal signals, the WinIQSIM™/AMIQ combination also allows the generation of defined signal impairments and additive interfering signals. Variation of bit rates and filtering are used to determine tolerance limits and to detect potential critical spots in new systems. By using the Vector Signal Generator SMIQ, fading and additive noise can be added to the complex signals provided by the AMIQ. In particular, the SMIQ meets the dynamic fading scenarios prescribed by the 3GPP standard.

Adjustment of I/Q modulators

More and more ICs and modules are equipped with differential I/Q inputs. In the case of DC coupling between the AMIQ and a modulator chip, for example, the I/Q signal can be superimposed by a DC (bias) voltage for setting the operating point (option AMIQ-B2 required). This DC voltage can be set separately for the I and Q channel. By superimposing a small offset voltage (user correction) in addition to this bias voltage, the RF carrier leakage in the modulator is minimized to obtain optimum data for the I/Q signal at the RF.

Digital components

The AMIQ's digital signal output (option AMIQ-B3) allows signals to be directly fed to baseband components with digital inputs.

The digital signal output is also optimal for testing digital/analog converters. Due to the selectable word length (8 bits to 16 bits), the test signal can be adapted to the specific requirements.

Certified Quality System
ISO 9001
DQS REG. NO 1954

Certified Environmental System
ISO 14001
REG. NO 1954

Specifications

Output memory		
Waveform length (data and markers)		
Clock rate – Slow mode (10 Hz to 4 MHz)		24 to 4000000/16000000 in steps of one
Clock rate– Fast mode (2 MHz to 100 MHz)		24 to 4000000/16000000 in steps of four
Amplitude resolution of data words		selectable word length 8 bit to 14 bit; up to 16 bit at digital output
Marker channels		can be used as marker or trigger outputs (for word lengths up to 14 bit)
Number		4
Multisegment waveform		max. 30 segments
Segment changeover time		
without clock change		4 ms typ.
with clock change		12 ms typ.
Clock generation		
Clock range		10 Hz to 100 MHz
Setting range		10 Hz to 105 MHz[1]
Resolution		1 x 10^{-7}
External clock input		
Clock rate		10 Hz to 4 MHz (slow mode) 2 MHz to 100 MHz (fast mode)
Reference frequency		
Internal reference output		
Frequency		10 MHz
Aging (after 30 days of operation)		1 x 10^{-5}/year
Temperature effect (0°C to 45°C)		<2 x 10^{-6}/°C
Level, rms		0.5 V (into 50 Ω)
Frequency adjustment		electronic
External reference input		
Frequency		10 MHz
Level, rms		0.1 V to 2 V
Input impedance		50 Ω
Signal output		
Outputs		I and Q[2]
Output impedance		50 Ω
Output voltage (V_p into 50 Ω)		
Fix mode		0.5 V, same for both channels
Amplitude fine variation		±10%, separately for each channel
Resolution		0.01%
Level difference between the two channels		<0.2% (at 1 kHz, after auto-alignment)
Residual DC offset		<0.5 mV, 0.1 mV typ. (after auto-alignment)
DC fine variation		±30 mV typ.
Resolution		30 µV
SFDR[3] (sinewave 1 MHz, clock rate 10 MHz)		>70 dB, 80 dB typ.
Variable mode		0 V to 1 V, separately adjustable for each channel
Resolution		3 digits
Residual DC offset		<5 mV, 1 mV typ. (after auto-alignment)
DC fine variation		±70 mV typ.
Resolution		70 µV
SFDR[3] (sinewave 1 MHz, clock rate 10 MHz)		>50 dB (level >0.1 V), 70 dB typ. (level >0.5 V)
Skew between I and Q channel (filter off, clock rate 10 MHz, fix mode)		
Fine variation		±1 ns typ.
Resolution		<10 ps
Rise time		5 ns typ.
Adjacent-channel power		
WCDMA 3GPP FDD		
Test model 1 (64 DPCH channels)		
Offset 5 MHz		–78 dBc typ.
Offset 10 MHz		–78 dBc typ.
Error vector		
IS-95 (QPSK)		0.35% typ. EVM (rms)
GSM (GMSK)		0.2° typ. phase error (rms)
DECT (2-FSK)		0.9% typ. FSK error
NADC, PHS (π/4DQPSK)		0.3% typ. EVM (rms)
Filters		
Operating modes		off (no filter), internal or external filter
Internal filters		
25 MHz		elliptic, 7th order + delay equalizer
Freq. response	Amplitude	0.15dB typ. up to 25 MHz
	Group delay	500 ps typ. up to 20 MHz
I/Q imbalance	Amplitude	0.05 dB typ. up to 25 MHz
	Group delay	200 ps typ. up to 20 MHz
Stopband attenuation		70 dB from 75 MHz
2.5 MHz		elliptic, 7th order + delay equalizer
Freq. response	Amplitude	0.15 dB typ. up to 2.5 MHz
	Group delay	5 ns typ. up to 2 MHz
I/Q imbalance	Amplitude	0.05 dB typ. up to 2.5 MHz
	Group delay	1 ns typ. up to 2 MHz
Stopband attenuation		70 dB from 7.5 MHz
External filters		one filter can be connected for each channel, BNC connectors on rear panel
Impedance		50 Ω
Trigger		
CONT mode		repetitive output of loaded waveform after occurrence of trigger
SINGLE mode		single output of loaded waveform after occurrence of trigger
GATED mode		start of (repetitive) waveform output after occurrence of trigger until end of trigger event
Trigger signal		via remote control or trigger input
Trigger input		BNC connector, selectable polarity
Input level		TTL
Max. permissible input voltage		–0.5 V to 6 V
Pulse width (clock rate –slow mode)		min. 200 ns + 1sample
Pulse width (clock rate – fast mode)		min. 11samples
Delay between trigger input and output of first data word		
Slow mode		220 ns + (1sample + 20 ns) jitter
Fast mode		21samples + 1sample jitter
Marker outputs		
Number of outputs		4, BNC connectors
Level		TTL, can be terminated into 50 Ω, (high >2 V)

BER measurement (option AMIQ-B1)

Data supplied by the DUT can be compared with a nominal random bit sequence; the results are transferred to the host computer (via the currently used remote control); the BER measurement can be controlled from WinIQSIM™ and SMIQ.

Pseudo random bit sequences	2^9–1, 2^{11}–1, 2^{15}–1 , 2^{16}–1, 2^{20}–1, 2^{21}–1, 2^{23}–1
Clock rate	max. 20 MHz
Clock source	each valid bit requires a clock, which is supplied by the DUT or the AMIQ
Sync period	24 clocks
Interface	9-pin D-SUB connector, D-SUB BNC cable supplied in addition
Data	TTL
Data enable	TTL
Clock	TTL
Restart	TTL
Setup time	10 ns
Hold time	2 ns
Polarity	normal and inverted (data, clock, data enable)
Measurement time	selectable through max. number of data or error bits (max. 2^{31} bit), continuous measurement
Measurement results	BER in ppm (when set number of data or error bits is attained), not synchronized, no clock from DUT

Differential I/Q outputs (option AMIQ-B2)[4]

Provides the inverted $\overline{I}$ and $\overline{Q}$ signals and allows a DC voltage to be simultaneously superimposed on the output signal.

Outputs	I, $\overline{I}$, Q and $\overline{Q}$
Operating mode	single/differential, selectable
Output impedance	50 Ω when on, 50 Ω or high Z when off
Bias voltage (EMF, to ground)	–2.5 V to +2.5 V (±10 mV) for both I and Q channels separate, common setting for I and $\overline{I}$ or Q and $\overline{Q}$
Resolution	<1.5 mV
Difference between I and $\overline{I}$ or Q and $\overline{Q}$	<0.5% + 1.5 mV
Output voltage (differential EMF between the I and $\overline{I}$ or Q and $\overline{Q}$ outputs, unless otherwise specified, V_p)	
Fix mode	2 V, same for both I and Q channels
Level difference I ↔ Q	<0.5% (at 1 kHz, after auto-alignment)
I ↔ $\overline{I}$ (Q ↔ $\overline{Q}$)	<0.5% (at 1 kHz, after auto-alignment)
Residual DC offset	<1 mV (to ground, after auto-alignment)
DC fine variation	±120 mV typ.
Resolution	120 μV
Variable mode	0 V to 4 V, separately adjustable for I and Q channels
Resolution	3 digits
DC fine variation	±280 mV typ.
Resolution	280 μV
Max. output voltage ($V_{signal} + V_{voltage}$)	<2.5 V (to ground)

Digital I/Q output (option AMIQ-B3)

Output	68-pin SCSI connector (mini D-SUB, half pitch)
Channels	I and Q
Resolution	8 bit to 16 bit (selectable, no marker output for word lengths >14 bit)
Max. clock frequency	100 MHz (if an external clock is used, the internal delay time from 20 ns to 25 ns between the input clock and the output data has to be taken into account above 40 MHz)
Output impedance	30 Ω to 50 Ω typ., high impedance with low level at pin 66
Output level	LVT or ABT level (data, marker and clock); the high level of the data, marker and clock signals is automatically adapted to the selected supply voltage for external circuits
V_{cc} output	+3.3 V or +5 V
Remote control and memory	via IEC625-2 (IEEE488) and RS-232-C
Command set	SCPI 1996.0 with extensions
IEC/IEEE interface functions	SH1, AH1, T6, L4, SR1, RL1, PP1, DC1, DT1, C0
Mass memory	floppy disk drive (3.5", 1.44 MB), hard disk 3 GB/6 GB (AMIQ03/04)
Download time (4000000 I/Q samples from built-in hard disk)	27 s

General data

Nominal temperature range	0 °C to +45 °C; meets IEC68-2-1 and IEC68-2-2
Storage temperature range	–40 °C to +70 °C
Damp heat	95% relative humidity at +40 °C; meets IEC68-2-3
Vibration, sinusoidal	5 Hz to 150 Hz, max. 2 g at 55 Hz, 0.5 g const. 55 Hz to 150 Hz, meets IEC68-2-6, IEC1010-1 and MIL-T-28800D class 5
Electromagnetic compatibility	meets EN50081-1 and EN50082-1 (EMC Directive of EU)
Immunity to RFI	10 V/m
Power supply	100 V to 120 V ± 10%, 50 Hz to 400 Hz, 200 V to 240 V ± 10%, 50 Hz to 60 Hz, autoranging, 150 VA
Safety	meets DIN EN 61010-1, 1994-03 CAN/CSA-C22.2 No. 1010.1-92 UL Std. No. 3111-1 IEC61010-1
Dimensions (W x H x D)	427 mm x 88 mm x 450 mm
Weight	8.7 kg

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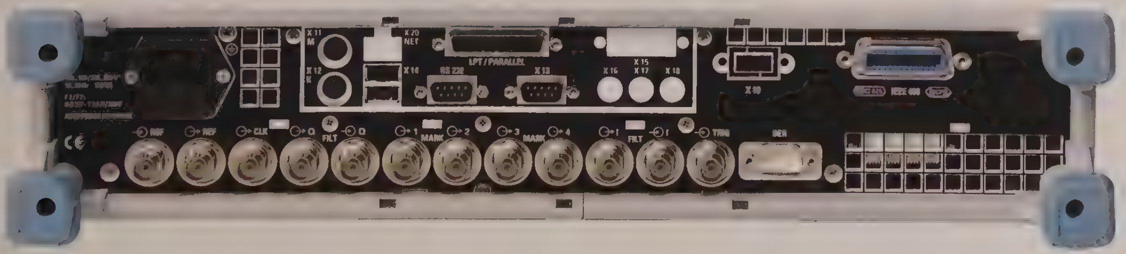
[1] Specs at clock >100 MHz not guaranteed, max. ambient temperature +35 °C.

[2] $\overline{I}$ and $\overline{Q}$ in addition when option AMIQ-B2 is used

[3] Spurious-free dynamic range

[4] All data not specified here are identical to those of the AMIQ without option B2 (I and Q only).



Ordering information

I/Q Modulation Generator	AMIQ	
4 Msamples		1110.2003.03
16 Msamples		1110.2003.04
Accessories supplied		
WinIQSIM™ version for Windows 95/98/NT/2000 on CD-ROM; manual, power cable, AMIQ operating manual		
Options		
BER Measurement	AMIQ-B1	1110.3500.02
Differential I/Q Outputs	AMIQ-B2	1110.3700.02
Digital I/Q Output	AMIQ-B3	1122.2103.02
Rear I/Q Outputs	AMIQB19[1]	1110.3400.02
Digital Standards		
IS-95	AMIQK11	1122.2003.02
CDMA2000	AMIQK12	1122.2503.02
WCDMA TDD Mode (3GPP)	AMIQK13	1122.2603.02
TD-SCDMA	AMIQK14	1122.2703.02
OFDM Signal Generation	AMIQK15	1122.2803.02
Recommended extras		
19" Rack Adapter	ZZA-211	1096.3260.00

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[1] Not with option AMIQ-B2. Marker outputs 3 and 4 not provided when this option is fitted

PD 0757 3 · I/Q Modulation Generator AMIQ · Trade names are trademarks of the owners · Subject to change · Data without toleranc al values
Printed in Germany 1201

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I/Q Modulation Generator AMIQ

[illegible] approaches in the generation of complex I/Q signals

- 14-bit resolution
- 4 000 000/16 000 000 sample memory depth
- 100 MHz sample rate
- 78 dB ACP dynamic range (typical of 3GPP FDD)
- Integrated hard disk and floppy disk drive
- Optional BER measurement (AMIQ-B1)
- Optional differential I/Q outputs (AMIQ-B2)
- Optional digital I/Q output (AMIQ-B3)

ROHDE & SCHWARZ

The ultimate in I/Q signals

[illegible]

- 100 MHz clock rate per channel
- Up to 16000000 samples per channel
- Generation of broadband digital communication signals (e.g WCDMA, HiperLAN2 and IEEE802.11a)
- Built-in hard disk for storage of calculated signals
- Downloading of calculated waveforms and signals also from integrated floppy disk drive
- Antialiasing filter featuring excellent frequency response and group delay
- Auto-alignment and additional user correction of amplitude and offset
- Fine adjustment of I/Q skew
- Wide dynamic range through the use of 14-bit D/A converter, ideal for multicarrier applications
- Excellent ACP (adjacent-channel power) values with WCDMA 3GPP FDD signals of typically –78 dBc for test model 1 with 64 channels

[illegible]

The number of systems based on complex digital modulation methods has dramatically increased in every field of communications. I/Q modulation is therefore gaining importance for the development of such modulation methods. The Modulation Generator AMIQ and the Simulation Software WinIQSIM™, which is described in a separate data sheet (PD 0757.6940), open up new dimensions for the generation of I/Q signals.

The AMIQ is a dual-channel modulation generator that has especially been designed for use as an I/Q source. It is programmed and set with WinIQSIM™. Alternatively, the AMIQ can be operated from the Vector Signal Generator SMIQ.

Of course, the AMIQ features full remote-control capabilities via the GPIB/IEEE and RS-232-C interfaces.

Each channel can store up to 16000000 samples. Sequences of sufficient length can thus be generated even at high symbol rates. Featuring clock frequencies of up to 100 Msample/s and a high amplitude resolution of 14 bit at the analog signal output and up to 16 bit at the digital signal output, the AMIQ is the ideal source for any digital modulation signal.

An automatic amplitude/offset alignment as well as fine adjustment of the skew provide excellent symmetry of the two channels which previously was extremely difficult to attain with dual-channel ARB generators. The error vector is thus minimized.

The filters have been optimized regarding group delay, frequency response and matching between the two channels for use as an I/Q modulation source.

Typical applications of the AMIQ and WinIQSIM™ not only include driving the I/Q inputs of a vector signal generator; the combination is also ideal for direct applications in the baseband, such as testing I/Q modulators/demodulators.

The digital signal output (option AMIQ-B3) opens up further applications in the baseband: digital/analog converters (DACs) or digital input base stations can be tested, for example.

[illegible]

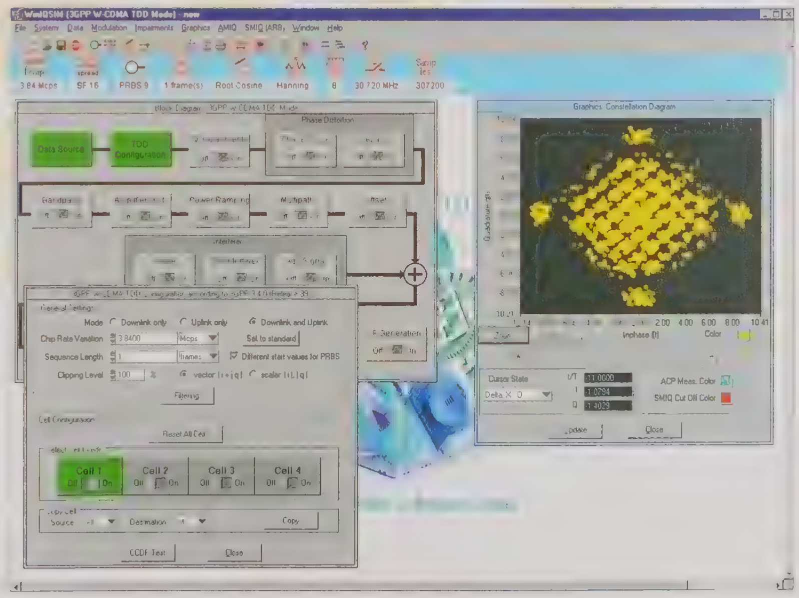
- Single-carrier signals
- Multicarrier signals (up to 512 modulated or unmodulated carriers)
- Multicarrier mixed signals (up to 32 differently modulated carriers)
- User-defined CDMA signal scenarios
- Addition of impairments
- Data editor for creating any TDMA frame configuration
- Predefined files for TDMA mobile radio standards (GSM, GSM-EDGE, DECT, NADC (IS54C/IS136), PDC, and test models 1 to 4 for WCDMA 3GPP FDD)
- IF signal calculation
- Graphic display of calculated signals (constellation diagram, vector diagram, i(t)/q(t), magnitude and phase, eye pattern, spectrum, etc)
- Remote control of the AMIQ
- The import system allows data from other software programs to be read in via the TCP/IP and DDE interfaces

*) For more details see data sheet PD 0757.6940

Versatile to the last detail

WinIQSIM™ is a Windows software program for calculating I and Q baseband signals. Its functionality ranges from single-carrier modulation, generation of multicarrier, CDMA and WCDMA signals through to TDMA frame configuration with the help of a convenient data editor. All modulation parameters and impairments can be simulated for single-carrier, multicarrier as well as for CDMA signals. To put it in a nutshell: WinIQSIM™ is an indispensable tool for anyone engaged in modern digital modulation.

This Windows software enables the AMIQ to simply generate complex modulation signals. This includes modulation signals for WCDMA 3GPP, which is similar to QPSK, or 8PSK EDGE modulation with 3π/8 shifting for the EDGE enhancement in the GSM standard. OFDM, which is used for HIPERLAN/2, and where a data stream is transferred via a large number of carriers, is a special modulation format. For generating this type of signal, the WinIQOFDM software (see www.rohde-schwarz.com) is used.



General Settings
Mode ○ Downlink only ○ Uplink only ● Downlink and Uplink
Chip Rate Variation 3.8400 Mcps
Sequence Length 1 frames
☑ Different start values for PRBS
Clipping Level 100 % ● vector |i+jq| ○ scalar |i|,|q|

One modulation generator ...

Outstanding quality

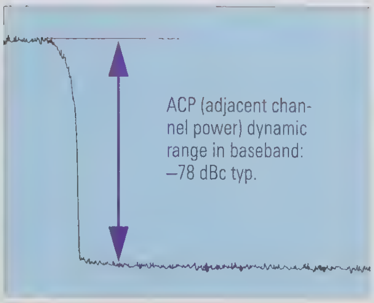
In addition to the great memory depth of up to 16000000 samples, the AMIQ is outstanding especially for its wide dynamic range and excellent spectral purity. For WCDMA signals, low adjacent-channel power (ACP) in the baseband is thus ensured. The built-in filters are designed for flat frequency response and constant group delay.

Two identical channels

For an I/Q source, it is especially important for the two channels to be identical since any difference would inevitably cause an additional modulation error.

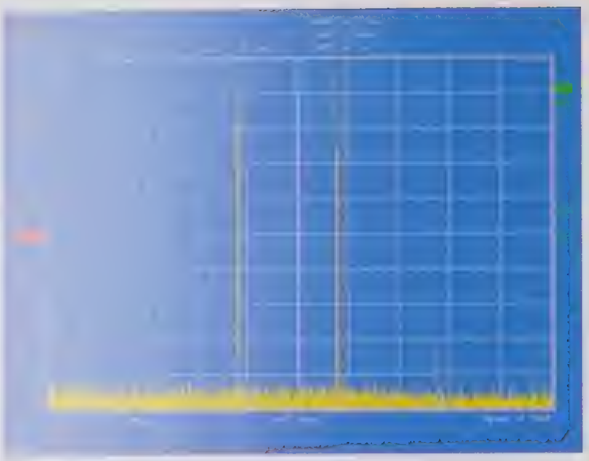
Automatic internal alignment of offset and amplitude of the I and Q channels guarantees high performance. Small amplitude or offset errors of the connected device under test can be user-corrected for overall system alignment. This user correction is independent of the automatic internal alignment.

Skews between the I and Q channels, which may be caused, for example, by slight differences in the connecting cables between the AMIQ and the vector signal generator, can be compensated with a resolution of approx. 10 ps.

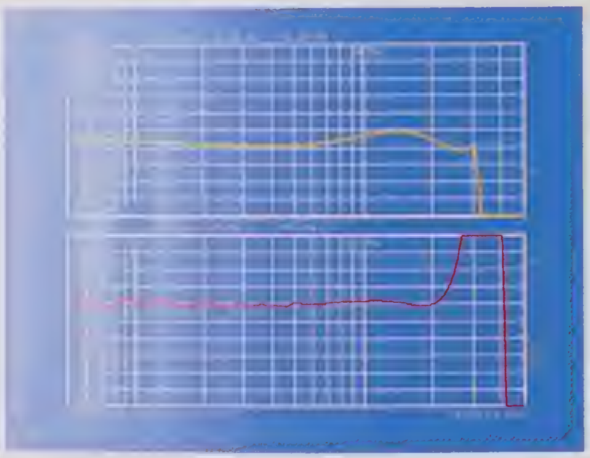


ACP (adjacent channel power) dynamic range in baseband: –78 dBc typ.

Intermodulation characteristic of the AMIQ at 50 MHz clock rate



Frequency response and group delay of 25 MHz output filter



All these features are the basis for the outstanding modulation performance of the AMIQ.

Synchronization capabilities

The signal output can be externally controlled. The clock rate of the I/Q output can be adapted to the device under test by means of an external clock. Four user-programmable marker outputs can be synchronized to the desired sample and used, for example, to generate sync pulses at the beginning of a timeslot or to drive the power ramping input of an RF signal generator.

BER measurement

Measuring the bit error rate has become a frequently used method for the verification of digital communication systems (e.g. measuring the sensitivity or selectivity of receivers, subsystems and components). The **option AMIQ-B1** allows the AMIQ to be used for BER (bit error rate) measurements. The device under test (DUT) must deliver the data to be tested and the associated clock. If the DUT does not have its own clock, the clock can be generated by the AMIQ and output via one of the four user-programmable marker channels. The built-in BER tester compares the data with the nominal data

... satisfying all requirements

and calculates the bit error rate. The result of the BER measurement is available via the remote-control interface. Various standard PRBS sequences (PN9, PN15, etc) are used as nominal data.

The BER measurement has an integrating function, i.e. at the wrap-around point of a PRBS sequence the bit error measurement is stopped and restarted by a control signal at the restart input without the previous result being cleared. All partial results are added until the predefined total number of data bits or error bits is attained. Irrelevant data sequences (e.g. preambles) are blanked, if necessary, by means of the control signal at the data enable input so that they do not invalidate the BER measurement. The PRBS sequence and the two control signals (at the marker outputs of the AMIQ) are generated by means of WinIQSIM™.

Differential [illegible]

The **option AMIQ-B2** enhances the existing I and Q outputs by providing the inverted $\overline{I}$ and $\overline{Q}$ signal outputs.

To meet all requirements, the option AMIQ-B2 allows a DC (bias) voltage to be superimposed on the balanced modulation signal (e.g. for setting the operating point). This bias voltage can be set separately for the I and Q channels with high resolution.

Using the AMIQ-B2, unbalanced signals can be converted to balanced signals without requiring an external circuit.

Digital output

The **option AMIQ-B3** provides the digital I and Q waveform data for each channel at a 68-pin SCSI connector on the front panel. A resolution from 8 bits to 16 bits can be selected for the output signals. So it is possible, for example, to drive digital/analog converters (DACs) with different word lengths. By matching the word length, clock and level of the output data to the requirements of the DUT, the AMIQ provides TTL-similar digital signals that are optimally suited for testing digital modules.

Use in development

The AMIQ considerably enhances the variety of applications of a vector signal generator. It takes over where the internal modulation capabilities of a vector signal generator reach their limits. For example, signals can be generated with a bit rate higher than that which can be processed by the internal modulation coder of an RF generator. The variation capability of any modulation parameter including the superposition of impairments and the generation of IF signals with the aid of WinIQSIM™ is far beyond the facilities of a conventional signal generator. IQWizard[1] allows the conversion of existing signal data that was generated with the aid of mathematical programs, for example.

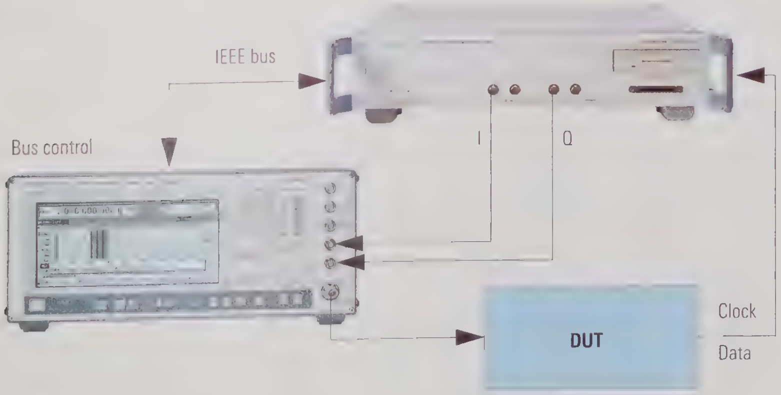
Use in production

For use in production environments, measuring instruments have to satisfy versatile requirements. One of the main points of interest is the space they require. Since the AMIQ has no built-in display, it is low in height which makes it especially suited for rackmounting in ATE (Automatic Test Equipment) systems. The AMIQ and WinIQSIM™ were designed for high-speed remote control via the IEC/IEEE bus. Predefined signals can be stored on the internal hard disk and quickly downloaded into the output memory.

3-year calibration cycle

Another benefit of the AMIQ is its 3-year calibration interval: it reduces costs and increases availability.

Example of bit error rate test



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[1] Can be downloaded from www.rohde-schwarz.com (Application Note 1MA28).

Operation

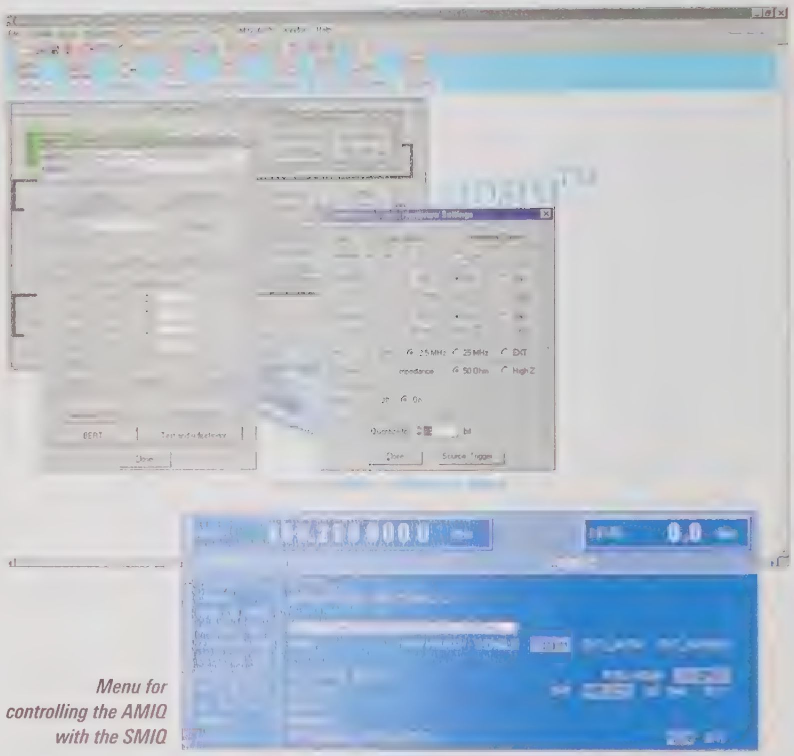
AMIQ, WinIQSIM™ and SMIQ a perfect team

The AMIQ is a black box without any control and display elements. There are several choices for operating the AMIQ:

Operation via WinIQSIM™
With WinIQSIM™, calculated signals are downloaded to the AMIQ hard disk or directly into the RAM of the AMIQ via IEC/IEEE bus or RS-232-C interface. In addition, all AMIQ functions can be set in a menu under WinIQSIM™.

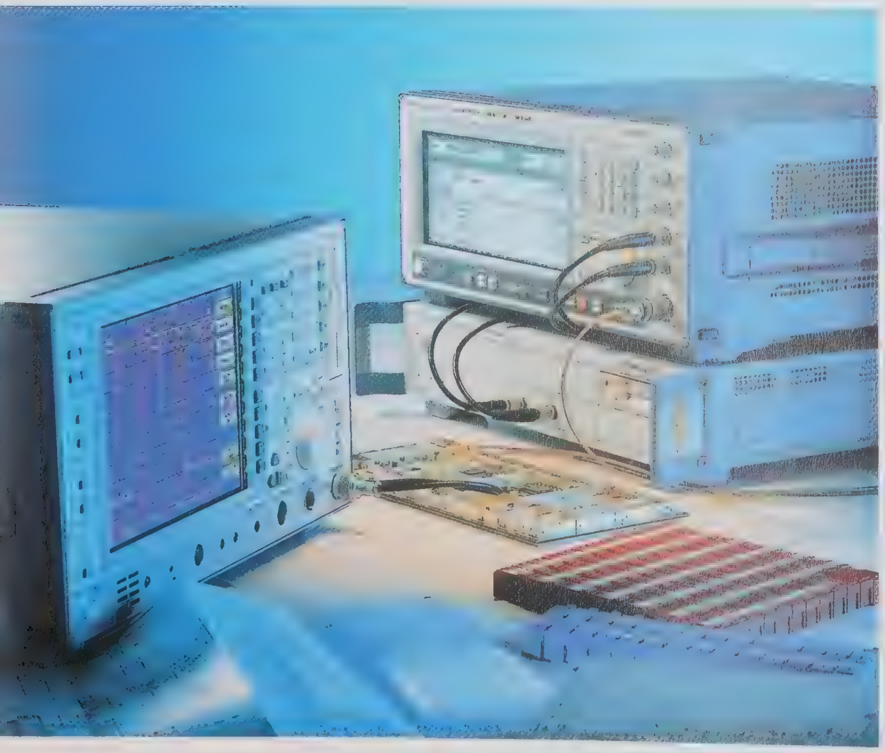
Operation from SMIQ
A PC with WinIQSIM™ is only required if new waveforms are to be calculated, since the once calculated signals can be stored on the hard disk of the AMIQ. In conjunction with the Vector Signal Generator SMIQ from Rohde&Schwarz, it is possible to select waveforms stored on hard disk or floppy and change the AMIQ parameters via a special menu. In this mode, the AMIQ acts as if it were an option to the SMIQ.

User interface for controlling the AMIQ with WinIQSIM™



Menu for controlling the AMIQ with the SMIQ

Operation in ATE systems
As with any other remotely controlled instrument, all functions of the AMIQ, e.g. downloading predefined waveforms from the integrated hard disk, can be controlled via the remote-control interface. In this operating mode, neither WinIQSIM™ nor an SMIQ is required.



Flexible generation of digitally modulated signals with the AMIQ and the SMIQ

Pseudo random bit sequences	2^9-1, $2^{11}-1$, $2^{15}-1$, $2^{16}-1$, $2^{20}-1$, $2^{21}-1$, $2^{23}-1$
Clock rate	max. 20 MHz
Clock source	each valid bit requires a clock, which is supplied by the DUT or the AMIQ
[illegible]	24 clocks
[illegible]	9-pin D-SUB connector, D-SUB BNC cable supplied in addition
[illegible]	TTL
[illegible]	TTL
[illegible]	TTL
[illegible]	TTL
[illegible]	10 ns
[illegible]	2 ns
[illegible]	normal and inverted (data, clock, data enable)
[illegible]	selectable through max. number of data or error bits (max. 2^{31} bit), continuous measurement
[illegible]	BER in ppm (when set number of data or error bits is attained), not synchronized, no clock from DUT

Differential I/Q outputs (option AMIQ-B2)[4]

Provides the inverted I and Q [illegible]ls and allows a DC voltage to be simultane- [illegible] ina

Output[illegible]	I, $\bar{I}$, Q and $\bar{Q}$
Operating m[illegible]	single/differential, selectable
Output imp[illegible]	50 Ω when on, 50 Ω or high Z when off
[illegible]	-2.5 V to +2.5 V (±10 mV) for both I and Q channels separate, common setting for I and $\bar{I}$ or Q and $\bar{Q}$
Resolution	<1.5 mV
[illegible]	<0.5% + 1.5 mV

Output voltage [illegible]EMF between the I and $\bar{I}$ or Q and $\bar{Q}$ outputs, unless otherwise s[illegible]

[illegible]	2 V, same for both I and Q channels
[illegible]	<0.5% (at 1 kHz, after auto-alignment)
[illegible]	<0.5% (at 1 kHz, after auto-alignment)
[illegible]	<1 mV (to ground, after auto-alignment)
DC fin[illegible]	±120 mV typ
Resolutio[illegible]	120 µV
Variable mod[illegible]	0 V to 4 V, separately adjustable for I and Q channels
Resolution	3 digits
DC fine variatio[illegible]	±280 mV typ
Resolution	280 µV
Max. output voltage (V_{signal} + [illegible])	<2.5 V (to ground)

Digital I/Q output (option AMIQ-B3)

Output	68-pin SCSI connector (mini D-SUB, half pitch)
Channels	I and Q
Resolution	8 bit to 16 bit (selectable, no marker output for word lengths >14 bit)
Max. clock frequency	100 MHz (if an external clock is used, the internal delay time from 20 ns to 25 ns between the input clock and the output data has to be taken into account above 40 MHz)
Output impedance	30 Ω to 50 Ω typ., high impedance with low level at pin 66
Output level	LVT or ABT level (data, marker and clock); the high level of the data, marker and clock signals is automatically adapted to the selected supply voltage for external circuits
V_{cc} output	+3.3 V or +5 V
Remote control and memory	via IEC625-2 (IEEE488) and RS-232-C
Command set	SCPI 1996.0 with extensions
IEC/IEEE interface functions	SH1, AH1, T6, L4, SR1, RL1, PP1, DC1, DT1, C0
Mass memory	floppy disk drive (3.5", 1.44 MB), hard disk 3 GB/6 GB (AMIQ03/04)
Download time (4000000 I/Q samples from built-in hard disk)	27 s

General data

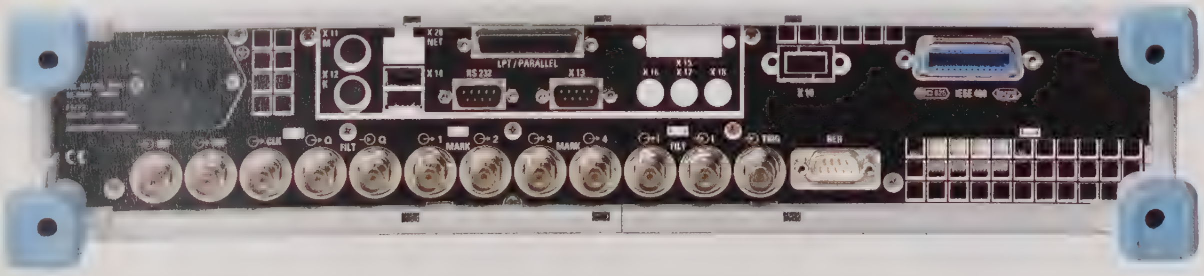
Nominal temperature range	0 °C to +45 °C; meets IEC68-2-1 and IEC68-2-2
Storage temperature range	–40 °C to +70 °C
Damp heat	95% relative humidity at +40 °C; meets IEC68-2-3
Vibration, sinusoidal	5 Hz to 150 Hz, max. 2 g at 55 Hz, 0.5 g const. 55 Hz to 150 Hz, meets IEC68-2-6, IEC1010-1 and MIL-T-28800D class 5
Electromagnetic compatibility	meets EN50081-1 and EN50082-1 (EMC Directive of EU)
Immunity to RFI	10 V/m
Power supply	100 V to 120 V ± 10%, 50 Hz to 400 Hz, 200 V to 240 V ± 10%, 50 Hz to 60 Hz, autoranging, 150 VA
Safety	meets DIN EN 61010-1, 1994-03 CAN/CSA-C22.2 No. 1010.1-92 UL Std. No. 3111-1 IEC61010-1
Dimensions (W x H x D)	427 mm x 88 mm x 450 mm
Weight	8.7 kg

Specs at clock >100 MHz not guaranteed, max. ambient temperature +35 °C

[2] $\bar{I}$ and $\bar{Q}$ in addition when option AMIQ-B2 is used

[3] Spurious-free dynamic range

[4] All data not specified here are identical to those of the AMIQ without option B2 (I and Q only)



Ordering information

I/Q Modulation Generator	AMIQ	
4 Msamples		1110.2003 03
16 Msamples		1110.2003.04
Accessories supplied		
WinIQSIM™ version for Windows 95/98/NT/2000 on CD-ROM, manual, power cable, AMIQ operating manual		
Options		
BER Measurement	AMIQ-B1	1110 3500 02
Differential I/Q Outputs	AMIQ-B2	1110 3700 02
Digital I/Q Output	AMIQ B3	1122 2103 02
Rear I/Q Outputs	AMIQB19[1]	1110 3400 02
Digital Standards		
IS-95	AMIQK11	1122 2003 02
CDMA2000	AMIQK12	1122 2503 02
WCDMA TDD Mode (3GPP)	AM QK13	1122 2603 02
TD-SCDMA	AM QK14	1122 2703 02
OFDM Signal Generation	AMIQK15	1122 2803 02
Recommended extras		
19" Rack Adapter	ZZA-211	1096 3260 00

Printed in Germany 1201 (

Simulation Software WinIQSIM™

- Calculation of digitally modulated I/Q and IF signals
- For driving the I/Q Modulation Generator AMIQ and the internal arbitrary waveform generator of the SMIQ (SMIQB60)
- Single-carrier, multicarrier, multicarrier mixed signals and CDMA signals
- WCDMA 3GPP FDD mode including data sets for the test models to 3GPP
- WCDMA 3GPP TDD mode optional (AMIQK13/SMIQK13)
- TD-SCDMA optional (AMIQK14/SMIQK14)
- IS-95 CDMA optional (AMIQK11/SMIQK11)
- CDMA2000 optional (AMIQK12/SMIQK12)
- Versatile data editor
- Superposition/simulation of impairments
- Graphic display
- Can be enhanced by import interface for additional software

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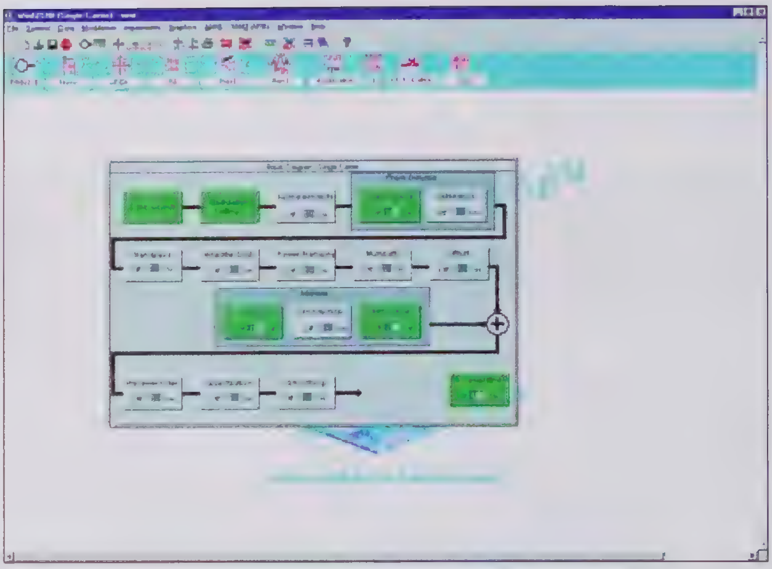
WinIQSIM™ was especially developed for the generation of digitally modulated signals. Complex signals can thus easily be generated. The graphic user interface allows intuitive operation, supported by context-sensitive help. The convenient way of creating any TDMA frame configurations with the aid of a data editor, and the generation of multicarrier signals as well as of complex WCDMA signals make WinIQSIM™ suitable for a wide range of applications. Moreover, additive impairments can be superimposed on a signal.

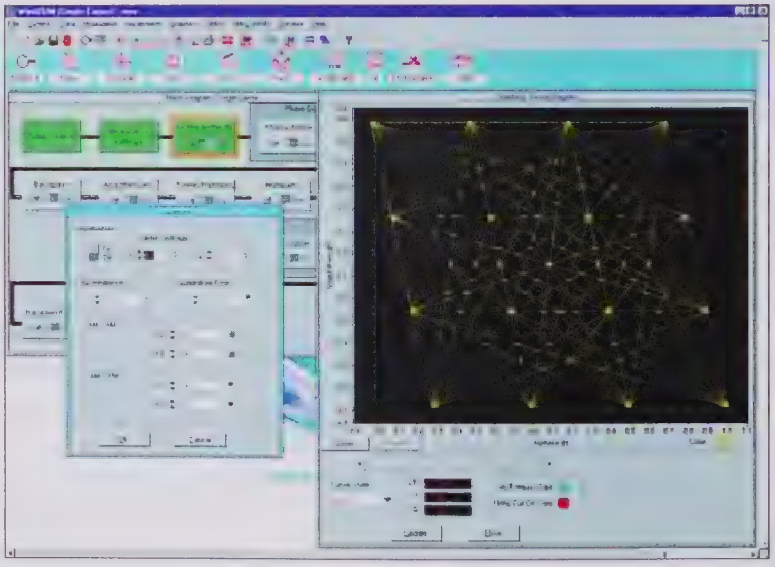
The signals generated with the aid of the WinIQSIM™ software can be output by the Arbitrary Waveform Generator AMIQ and the integrated solution in the SMIQ (option SMIQB60). WinIQSIM™ is provided with these two arbitrary waveform generators free of charge.



Clearly structured menus in the form of a signal flow chart

In developing WinIQSIM™, great importance was attached to user-friendly operation. The main parameters of a signal, for example, are indicated in a status line. The context-sensitive online help enables handling of even complex functions without consulting the manual.

The program always starts with the settings of the previous session, thus ensuring easy continuation of work.



Simulation of I/Q impairments, here for 16QAM

Modulation parameters such as type of modulation, coding, symbol rate, filter and window functions as well as oversampling can be set for a single-carrier signal.

Impairments which may be caused by a real I/Q modulator are also taken into consideration. It is, for example, easy to simulate I/Q imbalance, carrier leakage or quadrature error. The simulation of VCO noise or phase and frequency offsets of an oscillator are some of the very special features of WinIQSIM™. These and many other settings enable the user to take real impairments into account early in the development phase of components and modules.

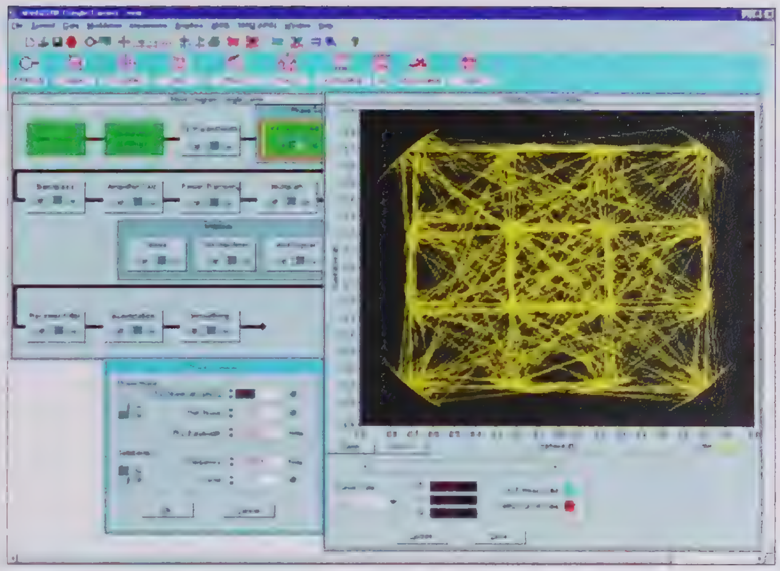
The comprehensive functionality of WinIQSIM™ allows various WCDMA systems to be realized: for example, both modes of the 3GPP standard, FDD (frequency division duplex) and TDD (time division duplex), are implemented. Signals can likewise be generated in accordance with the TD-SCDMA standard. And the North-American standards CDMA2000 and IS-95 are also included in WinIQSIM™.

All data and control channels defined by the relevant standard are supported. These include the synchronization channels such as primary and secondary common control channel (P-CCPCH and S-CCPCH) or synchronization channels (P-SCH and S-PCH).

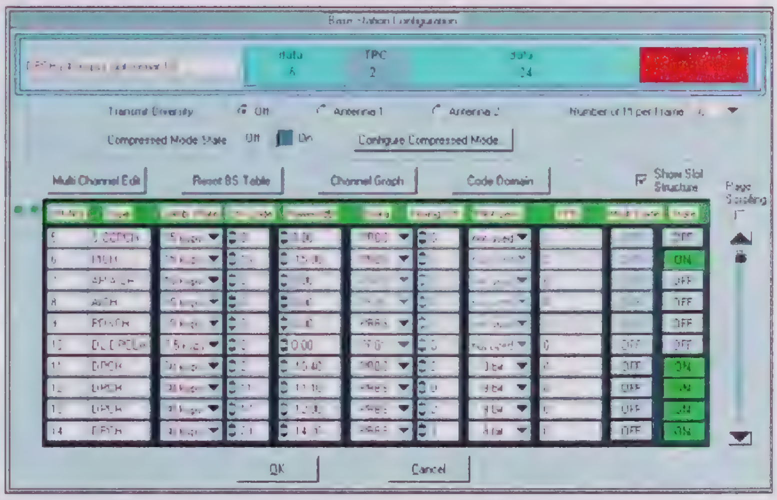
For the WCDMA standards as well as for the IS-95 and CDMA2000 standards, the orthogonal codes, data sources (PRBS, pattern or user-programmable sequences) and the power of the individual code channels can be varied, so that a large variety of signals can be generated.

WinIQSIM™ provides various display modes for checking the settings. The code domain display shows the distribution and occupancy of the individual channels in the code domain. Any code domain conflicts can be automatically resolved by a click. The channel graph includes all active channels. Synchronization and special channels are shown in red; data channels in green.

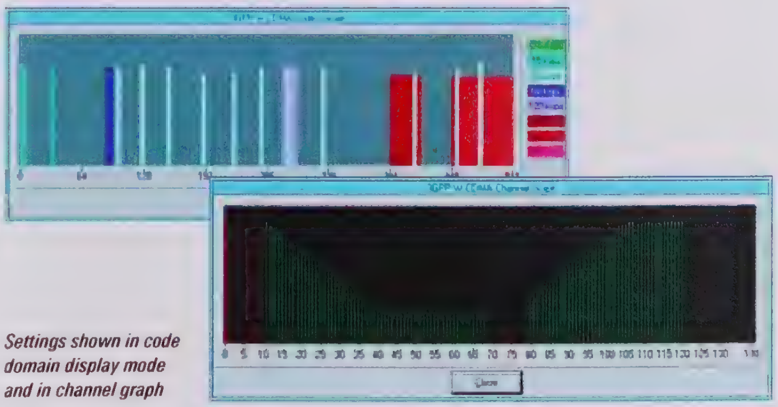
For statistical evaluation of the CDMA signal characteristics, WinIQSIM™ allows the complementary cumulative distribution function (CCDF) to be calculated (including the crest factor) and graphically displayed. In addition, the resulting adjacent-channel power can be calculated.



Simulation of defined phase noise on a 16QAM-modulated signal



Definition of a code channel scenario for WCDMA 3GPP FDD mode



Settings shown in code domain display mode and in channel graph

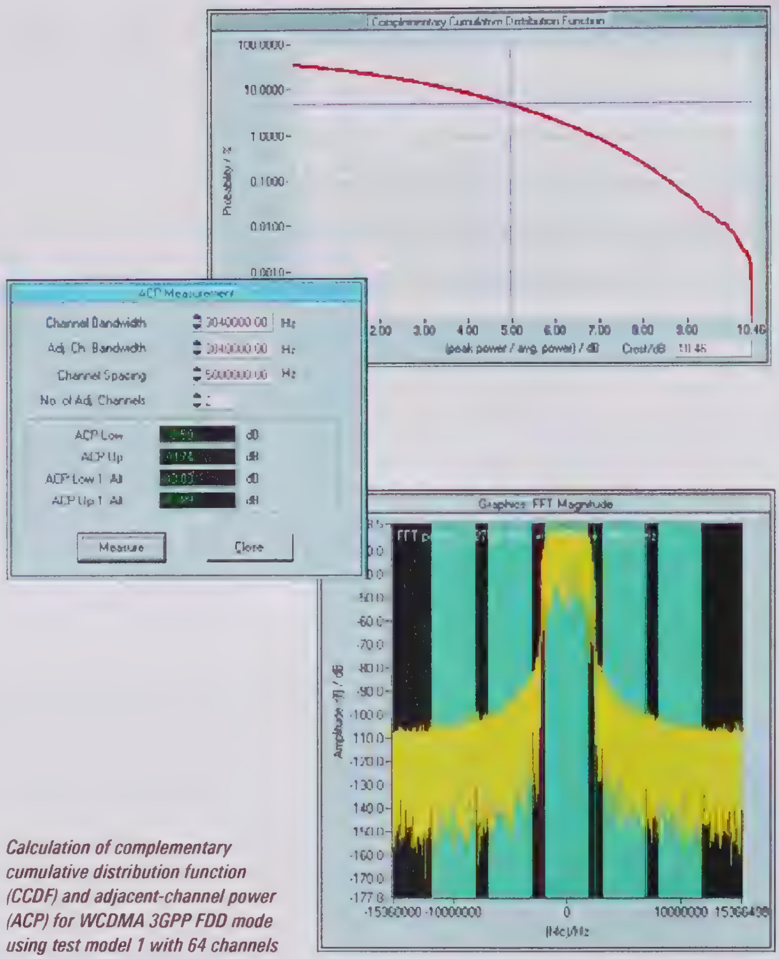
Depending on the selected symbol rate, up to 512 code channels with a chip rate of 3.84 Mcps are generated in the FDD mode for testing base stations under realistic as well as under worst-case conditions.

For this purpose, signals are generated which contain up to four mobile or base stations with different scrambling codes. WinIQSIM™ also allows the power of the individual data channels to be varied via TPC (transmit power control), which is used to control the power of the different channels in line with the 3GPP standard.

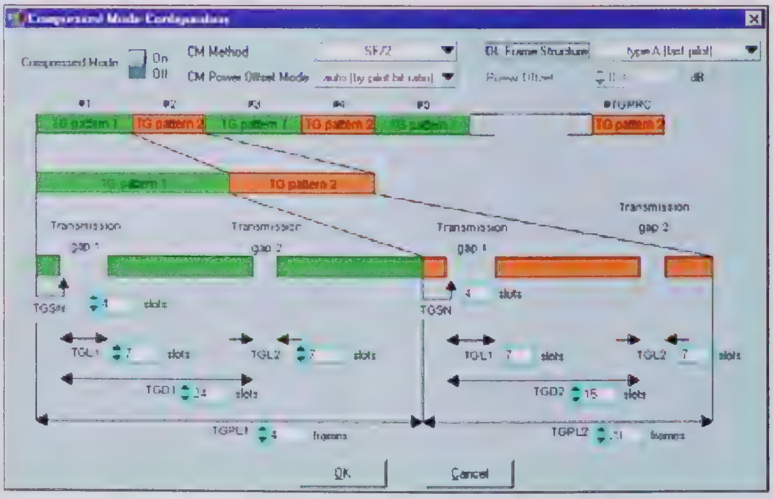
WinIQSIM™ supports the antenna diversity schemes specified by the 3GPP standard. Either the specification for antenna 1 or that for antenna 2 can be used so that the signal will be generated in line with the 3GPP specification.

In the uplink, the mobile station can operate in one of the three permitted modes: PRACH only (physical random access channel), PCPCH only (physical common packet channel) and DPCCH + DPDCH (dedicated physical control channel and dedicated physical data channel).

The versatile settings enable even very specific tests to be carried out. For 3GPP FDD, for example, the compressed mode is supported, which allows handover of a mobile station from a 3GPP FDD base station to a base station (3GPP FDD, 3GPP TDD or GSM) with a different frequency. For this purpose, transmission and reception of the 3GPP FDD signal has to be interrupted for a certain time. In this transmission gap, the mobile station can change to the frequency of the potential new base station in order to read, for example, the system information or the receive level of this base station. To allow the same data quantity to be transmitted in the remaining shorter time, data is compressed. WinIQSIM™ allows extensive user-defined settings for all physical layer compressed mode parameters.



Calculation of complementary cumulative distribution function (CCDF) and adjacent-channel power (ACP) for WCDMA 3GPP FDD mode using test model 1 with 64 channels



Editing of compressed mode

In the TDD mode of the 3GPP standard, the link directions of the individual slots can be conveniently selected. The user can define whether each timeslot is to act as an uplink or a downlink.

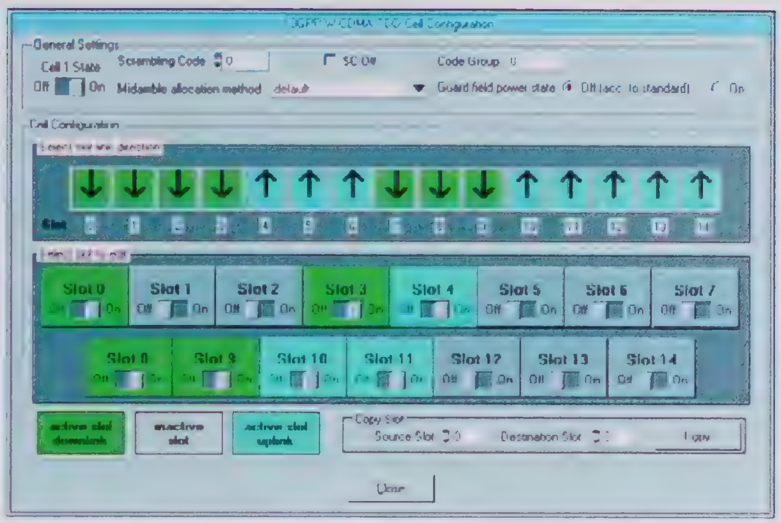
Up to four cells with 15 timeslots each can be generated; different spreading factors are permitted for each channel. For the data channels (DPCH), all spreading factors permitted by the standard are available.

In the TDD mode, it is very important to calculate the CCDF not only for the total signal, but also for a specific timeslot. Since the system is made up of timeslots that can be switched on or off independently of one another, only the CCDF of an active slot is often of interest. This can then be used, for example, to optimally design the output amplifier of a mobile phone, since the latter is active in one slot only.

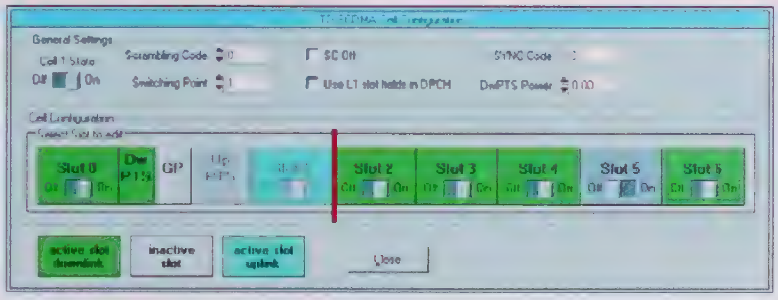
TD-SCDMA is basically similar to the TDD mode. The two modes differ in the chip rate, which is 1.28 Mcps for TD-SCDMA instead of 3.84 Mcps in the TDD mode. According to the TD SCDMA standard, the link direction of the individual slots cannot be selected by the user as conveniently as in the 3GPP-TDD mode, a fact that has been taken into account by WinIQSIM™.

With TD-SCDMA, special timeslots are provided for the uplink and the downlink. To carry out certain tests on mobile stations, only the downlink pilot may be active; however, WinIQSIM™ considers this fact by generating the downlink signals only.

With IS-95, the previous US standard for CDMA technology is included in WinIQSIM™. With CDMA2000, the following generation of the US standard has also been implemented. WinIQSIM™ supports the modes 1X with 1.2288 Mcps and 3X with 3.6864 Mcps; the 3X mode can optionally be generated according to the direct-spread or multicarrier method. Up to four mobile or base stations can be simulated simultaneously.

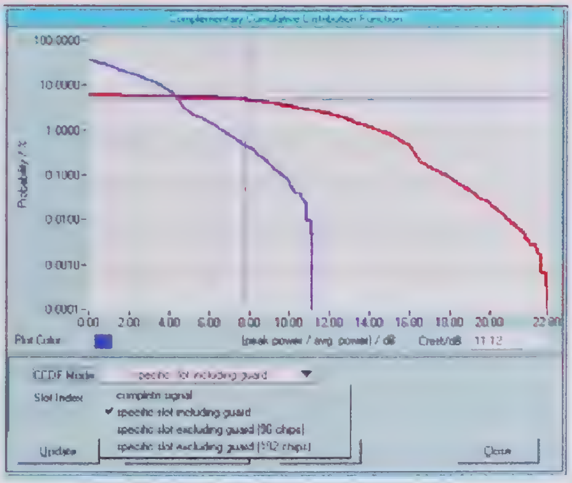


User-defined settings of the timeslots for 3GPP TDD mode



Configuration of TD-SCDMA signal

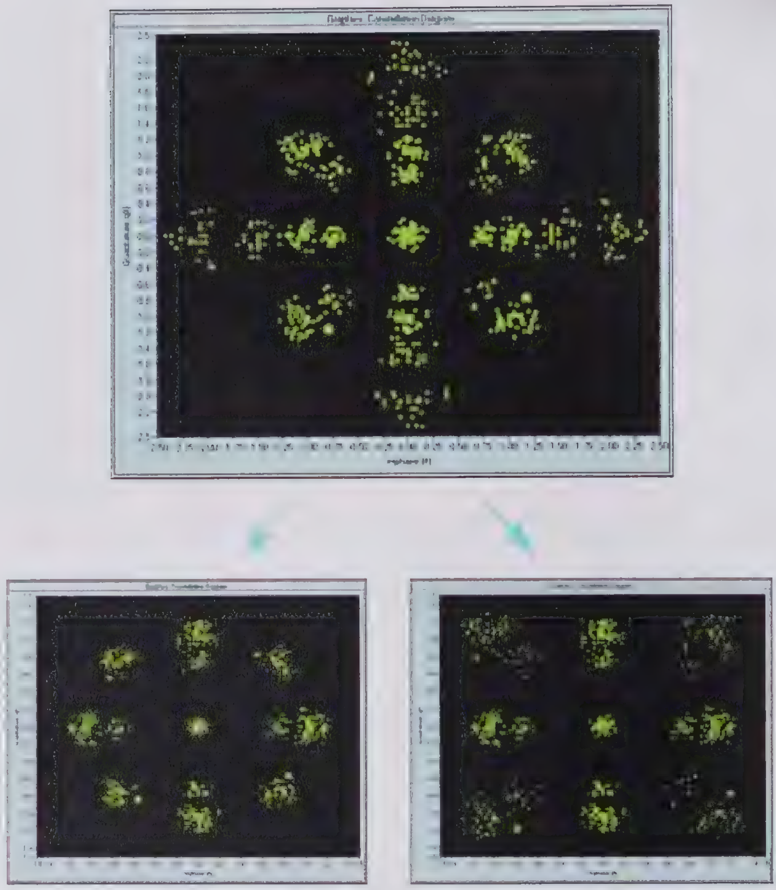
CCDF of a TDD signal calculated for the complete signal (red) and for an active timeslot (blue)



The open software concept of WinIQSIM™ allows continuous adaptation to the rapid development of third-generation mobile radio standards. The user is thus always up to the latest technical standard.

Due to the superposition of many code channels, high power peaks occur in all CDMA and WCDMA signals, which is reflected in a high crest factor. This means that a wide dynamic range is required for the transmission system with all its components such as amplifiers. Since extreme signal peaks are relatively rare, as can be seen from the CCDF, clipping of the signal peaks can be performed without essentially degrading the bit error rate. Clipping prior to baseband filtering does not cause a change in the frequency spectrum of the signal, either

The clipping level can be set between 1% and 100% relative to the maximum level peak. In the TDD mode of the 3GPP standard, and also with TD-SCDMA, scalar clipping is available in addition to the conventional vector clipping.

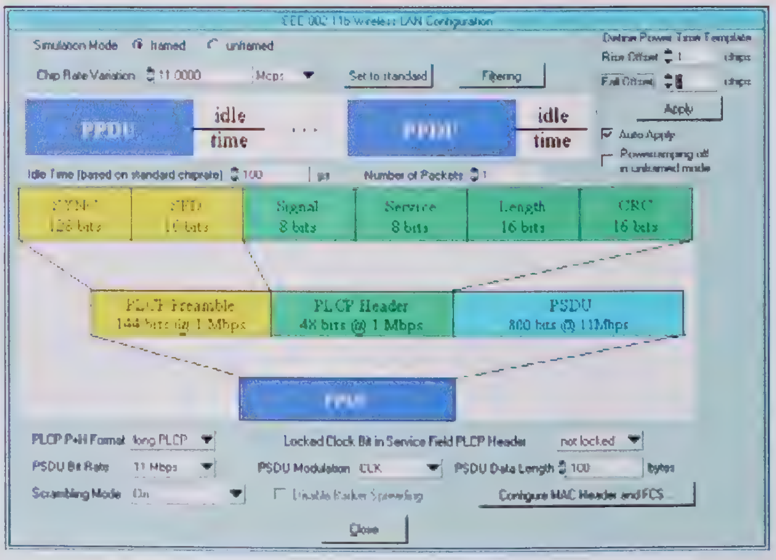


Effect of clipping on the constellation diagram with vectorial (bottom left) and scalar (bottom right) clipping with clipping level of 50% in each case

In addition to the comprehensive functionality for the mobile radio standards, WinIQSIM™ also covers the Wireless LAN standard IEEE 802.11b. The four data rates used by this standard (1 Mbps, 2 Mbps, 5.5 Mbps and 11 Mbps) as well as all the possible modulation modes (DBPSK, DQPSK, CCK and PBCC) are fully supported by WinIQSIM™. A direct sequence spread spectrum method is used for radio transmission. Irrespective of the data rate, a chip rate of 11 Mcps is used with this method.

Since data is transferred in packets with the IEEE 802.11b standard, WinIQSIM™ enables the number of packets, the packet length and the idle time between the packets to be entered. For test purposes, WinIQSIM™ can additionally simulate a continuous data stream without packet structure (unframed mode).

Other W-LAN standards (HiperLAN2 and IEEE 802.11a) are covered by the additional software program WinIQOFDM.



Simulation Mode ● framed ○ unframed

Chip Rate Variation 11.0000 Mcps

Define Power Time Template

Rise Offset 1 chips

Fall Offset 8 chips

☑ Auto Apply

☐ Powerramping off in unframed mode

Idle Time (based on standard chiprate) 100 µs

Number of Packets 1

PLCP P+H Format long PLCP

Locked Clock Bit in Service Field PLCP Header not locked

PSDU Bit Rate 11 Mbps

PSDU Modulation CCK

PSDU Data Length 100 bytes

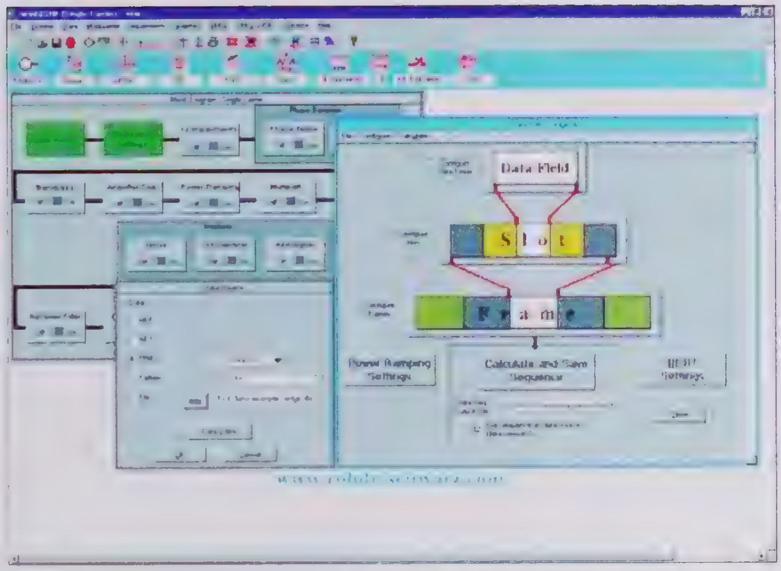
Scrambling Mode On

☐ Disable Barker Spreading

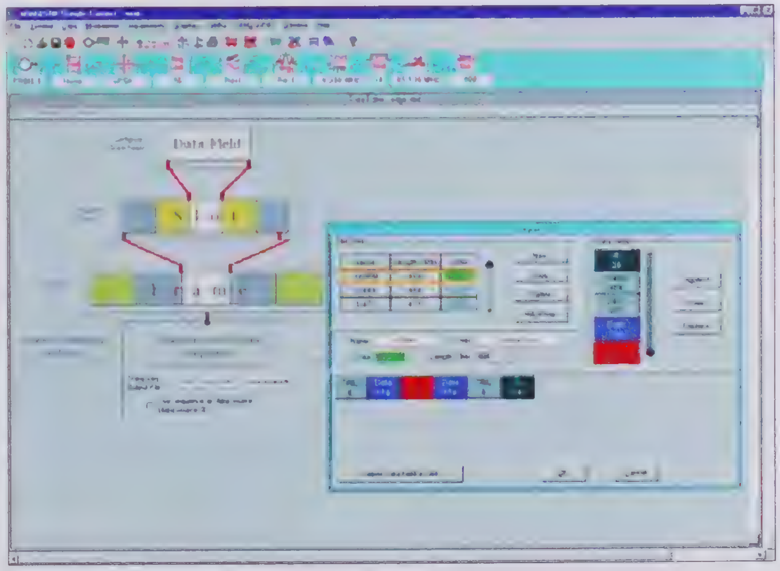
Operating menu for Wireless LAN standard IEEE 802.11b

Another special feature of WinIQSIM™ is the data editor for convenient generation of TDMA frame structures, which is especially designed for the single-carrier mode. WinIQSIM™ already provides preconfigured files for the main TDMA standards such as GSM, GSM/EDGE, DECT, PDC and NADC. A choice of different burst types with the associated data structure is available for the individual systems. Frame and timeslot configuration conform to the relevant standard. Basic configurations can easily be modified, stored and used again in subsequent tests.

Users particularly concerned with the definition or development of new TDMA standards are offered an almost infinite number of possibilities by the data editor. The structure of a TDMA signal with its basic elements (data fields of a burst) can be completely defined and successively configured into bursts and frames. In this way, it is possible to design an individual standard. In addition to the graphical representation of the data structures, power ramping can also be defined at the data level.



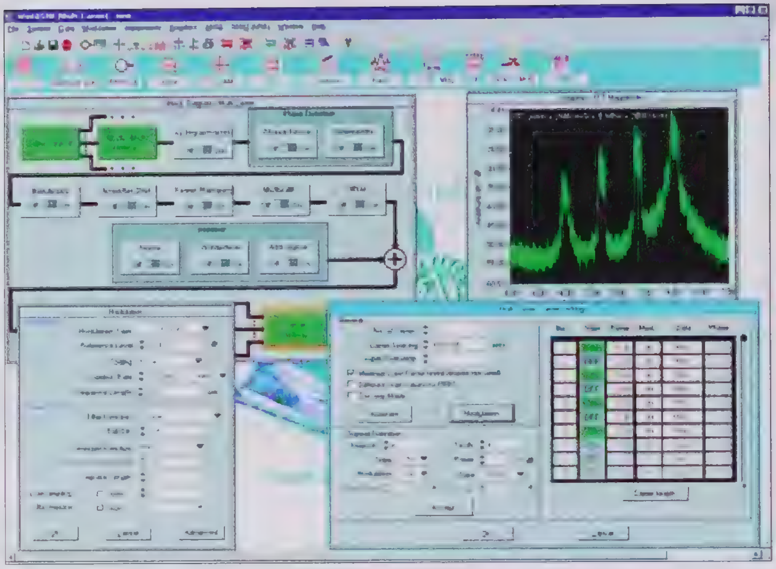
Main menu of data editor



Definition of slots in the data editor

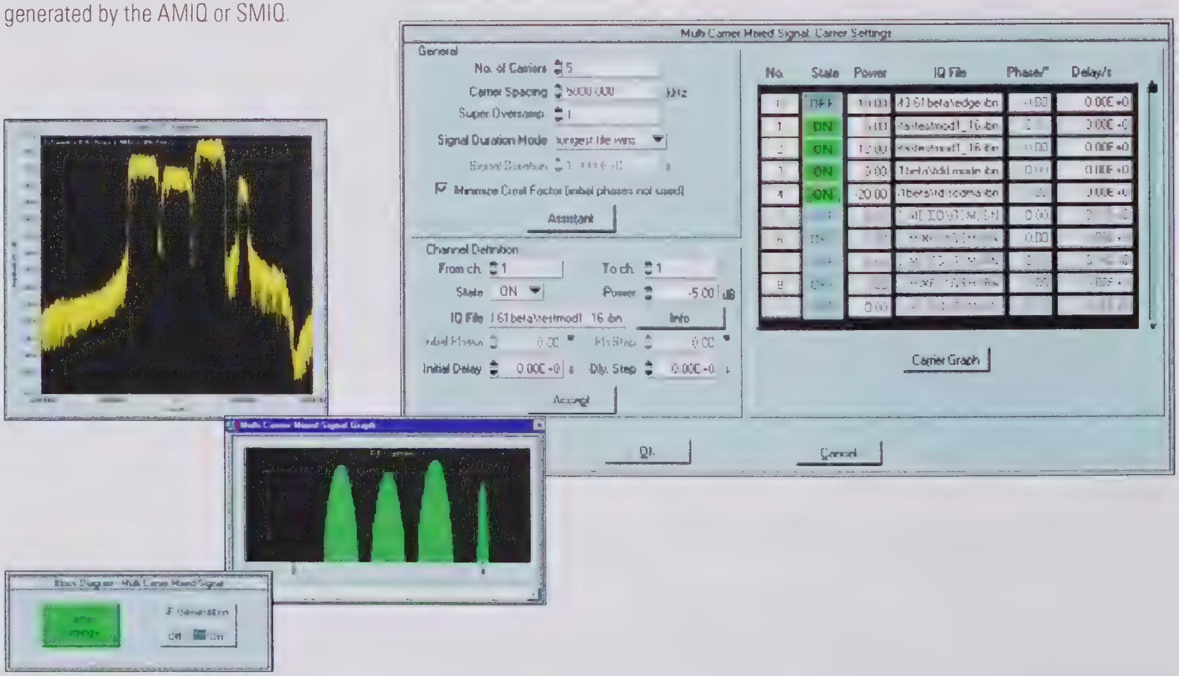
In addition to single-carrier signals, multicarrier signals with all their characteristic parameters such as number of carriers (up to 512), carrier spacing, modulation (same for all carriers) and carrier power can be simulated. In this way, composite signals consisting of modulated and unmodulated carriers or signals with several superimposed impairments can be generated. What makes this application so attractive is that only one generator is needed to produce these signals, which means an enormous cost benefit.

Another operating mode (multicarrier mixed signal mode) allows up to 32 differently modulated carriers to be combined with any signal from various systems (single-carrier, multicarrier, WCDMA 3GPP FDD and TDD, TD-SCDMA, CDMA2000, IS-95) at variable power levels. Signal scenarios such as several different WCDMA carriers can thus be simultaneously simulated and generated by the AMIQ or SMIQ.



Generation of a multicarrier signal

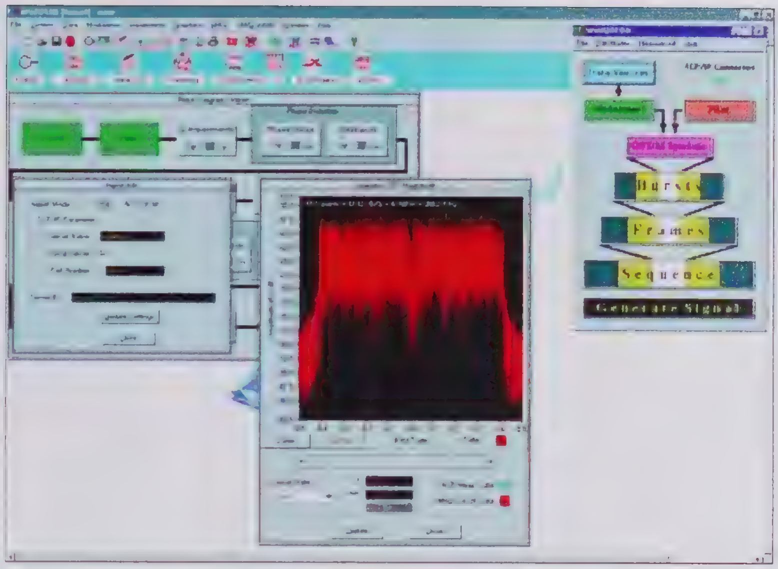
Generation of a multicarrier signal comprising two WCDMA 3GPP FDD signals, one WCDMA 3GPP TDD signal and one TD-SCDMA signal



Data from other PC programs can be read in via the import system. The TCP/IP or the dynamic data exchange (DDE) interface serves as the software interface.

Data can, for example, be imported from the WinIQOFDM software, which is used for generating OFDM-modulated signals. Through subsequent processing in WinIQSIM™, signal modifications such as baseband filtering and superimposed impairments can be applied to the signal to be generated

The import interface also forms the basis for further applications (e.g. "IQWizard", for more information see www.rohde-schwarz.com) or customer-specific enhancements

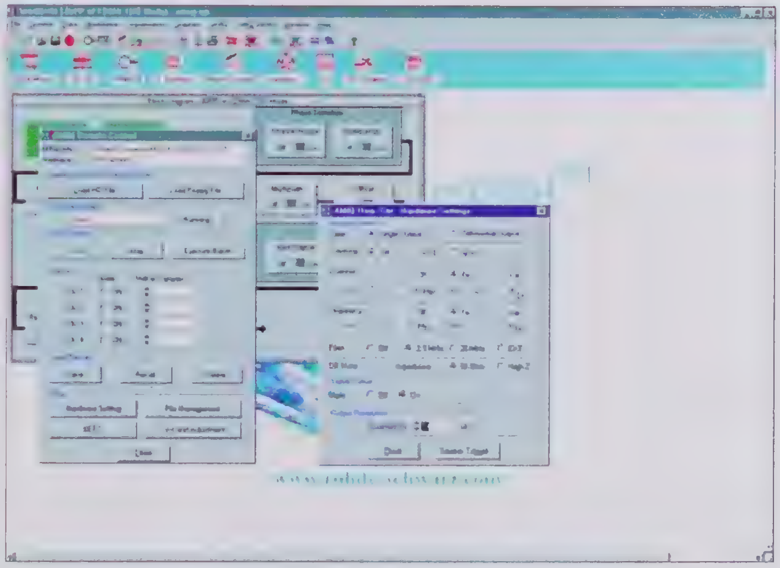


Functioning of the import system with WinIQOFDM software

The WinIQSIM™ PC program is used to control and operate the I/Q Modulation Generators AMIQ and the SMIQ-integrated solution SMIQB60

For the AMIQ , it provides file management on the internal hard disk, and controls the hardware settings and all other functions

The functionality of WinIQSIM™ regarding device control is especially important in bit error rate measurements with the AMIQ (option AMIQ-B1). In addition to performing the control functions, the software outputs the measurement results in a WinIQSIM™ window



User interface for controlling the AMIQ with WinIQSIM™

User interface	Windows interface with context-sensitive help
Systems	single-carrier, multicarrier, multicarrier mixed signal, WCDMA 3GPP FDD, WCDMA 3GPP TDD, TD-SCDMA, IS-95, CDMA2000

Simulation of digitally modulated single-carrier signals incl. TDMA

Modulation modes	
PSK	BPSK, QPSK, offset QPSK, p/4DQPSK, 8PSK, 8PSK EDGE;
Parameter	reference level = –10 dB to 3 dB PSK rotation = 0 to 15 · π/8
QAM	16/32/64/256QAM
Parameter	reference level = -10 dB to 3 dB
FSK	MSK, 2FSK, 4FSK, GTFM
Parameter	modulation index = 0.1 to 12 GTFM b = 0 to 1
User-specific modulation	definition of customized modulation modes (PSK, QAM, FSK) via data interface with up to 4.096 mapping states
Baseband filters	Fourier approximation design method with windowing
Digital filters	rectangular √cosine, α = 0.01 to 0.99 cosine, α = 0.01 to 0.99 Gaussian, B·T = 0.1 to 3.0 Gaussian EDGE partial response no filter
User-specific filter	customized filter defined via file interface, specification of impulse response in time domain with up to 1024 coefficients, different filter coefficients for I and Q channel possible
Window	rectangular Hanning Kaiser, β = 0.01 to 10.0 Hamming Chebyshev, ripple = 10 dB to 80 dB
Window length	1 to 32 (integer)
Oversampling	1 to 32 (integer)
Symbol rate	10 symb/s to max. 100 Msymb/s
Coding	Gray, Diff, Gray Diff, GSM Diff, NADC, TFTS, MSAT Diff, Phase Diff, none
Data sources	all 0, all 1, PRBS (7, 9, 11, 15, 16, 20, 21, 23), pattern (max. 79 bit), user-defined data sequence via file interface
Data editor	definition of TDMA data structures with modularity at three levels: data field, slot and frame, definition of power-time templates
Data fields	up to 50 different fields, length up to 1000 bit, data content: all 0, all 1, pattern (max. 79 bit) or PRBS
Slots	up to 24 different slots, any combination of up to 36 data fields
Frame	any combination of up to 36 slots
Sequence length	1 to max. 4 (16) Msamples (AMIQ03/AMIQ04)
Simulation of impairments and transfer characteristics	
I/Q impairment	carrier leakage I and Q (–50% to +50%) I/Q imbalance (–30% to +30%) quadrature offset (–30° to +30°) AM/AM conversion (k2; k3 –3 to +3 dB) AM/PM conversion (k2; k3 –30° to +30°)
Phase noise	simulation of impairments of phase-locked loop (VCO) and discrete spurious lines
Bandpass	simulation of bandpass at the RF with amplitude and group delay distortion
Amplifier models	amplifiers with soft and hard limiting, nonlinearities: AM/AM k3, k5 –3 dB to +3 dB; AM/PM k3, k5 –30° to +30°
Power ramping	ramp function: linear, cos^2 rise/fall time: 0 to 16 Tsym level: –80 dB to 0 dB
Multipath propagation	up to 6 paths with different delays, start phases and levels
Offset	phase offset: –180° to +180° frequency offset: –0.35 f$_{sample}$ to +0.35 f$_{sample}$
Additive impairments	
Noise	E_b/N_0 = –3 dB to +80 dB, bandwidth 0.5/1/2/4/8/16 f$_{symbo}$
Sinewave interferer	C/I = –3 dB to +80 dB, frequency –0.35 f$_{sample}$ to +0.35 f$_{sample}$
Superimposed signal	addition of a previously calculated signals, level –80 dB to +3 dB
Receiver filters	rectangular √cosine, α = 0.01 to 0.99 Gaussian, B·T = 0.1 to 3.0 user-specific (see above)
Quantization	I/Q resolution: 10^{-6} to 0.5; filter coefficient resolution: 10^{-6} to 0.5
Smoothing	smoothing the wraparound of the I/Q signal between signal end and signal start: in range 2 sample to 32 sample
Graphic output	user-selectable scaling, zoom function, delta marker; display modes: i(t), q(t), r(t), phi(t), r(t), f(t), eye I, eye Q, eye F, vector diagram, constellation diagram, magnitude/phase/group-delay spectrum, additionally CCDF and ACP (see below)
CCDF function	determination and graphic display of complementary cumulative distribution function with calculation of crest factor
ACP calculation	calculation of adjacent-channel power in the spectrum display (ACP up, low and ACP up 1st alt, low 1st alt)
IF signal generation	modulation of calculated I/Q signal to the IF range 0.01 MHz to 25 MHz (output to I channel of AMIQ)

Simulation of multicarrier signals with same or without modulation

Number of carriers	max. 512 carriers
Parameters of each carrier	state on/off, power, modulation on/off, data source, start phase
Modulation modes	same as with single-carrier system, each carrier can be modulated or not, modulated carriers use the same modulation mode
Baseband filtering	same as with single-carrier system, identical for all modulated carriers
Coding	same as with single-carrier system, identical for all modulated carriers
Data sources	4 different sources, 3 same as in single-carrier system, another PRBS source with different start values for different carriers
Data editor	same as with single-carrier system
Carrier power	–80 dB to 0 dB
Start phase of carrier CW signal	0° to 360° selectable for each carrier or automatic setting for minimizing the crest factor

Sequence length	1 to max. 4 (16) Msamples (AMIQ03/AMIQ04)
Simulation of impairments and transfer characteristics	same as with single-carrier system, identical for all modulated carriers
Smoothing	same as with single-carrier system
Graphic output	same as with single-carrier system
CDF function	same as with single-carrier system
ACP calculation	same as with single-carrier system
IF signal generation	same as with single-carrier system

Simulation of differently modulated multicarrier signals and signals of different systems on the carriers

Number of carriers	max. 32
Parameters of each carrier	state on/off, power, I/Q modulation file, start phase
I/Q modulation signal	an I/Q signal file onto which the carrier shall be modulated can be defined for each carrier; these signal files can be generated in all systems
Carrier power	–80 dB to 0 dB
Start phase of carrier CW signal	0° to 360° selectable for each carrier or automatic setting for minimizing the crest factor
Signal period	automatically adapted to longest or shortest carrier signal period or user-selectable (max. duration 4 (16) Msamples/sample rate, AMIQ03/AMIQ04)
Graphic output	same as with single-carrier system
CCDF function	same as with single-carrier system
ACP calculation	same as with single-carrier system
IF signal generation	same as with single-carrier system

3GPP (FDD) version	4.1 0 to 3GPP technical specifications TS25.211, TS25.213, TS25.141, TS25 101 and TS25.104
General settings	
Chip rate	
Standard	3.840 Mcps (15 slots/frame),
Range	10 cps to 100 Mcps
Link direction	uplink (reverse link) and downlink (forward link)
Sequence length	1 to 26 frames AMIQ03 (oversampling 4) 1 to 104 frames AMIQ04 (oversampling 4) 1 to 6 frames SMIQB60 (oversampling 2)
Baseband filter	
Standard	√cos, α = 0.22
Other filters	same as with single-carrier system
Clipping level	Setting of clipping value relative to highest peak in percent. Cipping takes place prior to baseband filtering and reduces the crest factor. The range is 1% to 100 %.
[illegible]	
[illegible]	up to 512 data channels (plus special channels) divided among up to four base stations (BS) with 128 code channels each
[illegible]	up to four mobile stations (MS) each operating in one of modes PRACH only, PCPCH only, DPCCH + DPDCHs
Physical channels in downlink	
P-CPICH	Primary Common Pilot Channel
Symbol rate	15 ksps, fixed
Channelization code	0, fixed
Slot structure	predefined symbols
S-CPICH	Secondary Common Pilot Channel
Symbol rate	15 ksps, fixed
Channelization code	0 to 255
Slot structure	predefined symbols
P-SCH	Primary Sync Channel
Symbol rate	15 ksps, fixed
Slot structure	synchronization code (SC)
S-SCH	Secondary Sync Channel
Symbol rate	15 ksps, fixed
Slot structure	synchronization code (SC)
P-CCPCH	Primary Common Control Physical Channel
Symbol rate	15 ksps, fixed
Channelization code	1, fixed
Slot structure	data
S-CCPCH	Secondary Common Control Physical Channel
Symbol rate	15, 30, 60, 120, 240, 480, 960 ksps
Channelization code	depending on symbol rate, 0 to max. 255
Slot structure	data, TFCI, pilot
PICH	Page Indication Channel
Symbol rate	15 ksps, fixed
Channelization code	0 to 255
Number of PIs per frame	18, 36, 72, 144
Slot structure	page indicator bits, not used bits
AP-AICH	Access Preamble Acquisition Indication Channel
Symbol rate	15 ksps, fixed
Channelization code	0 to 255
Slot structure	acquisition indicators, empty symbols
AICH	Acquisition Indication Channel
Symbol rate	15 ksps, fixed
Channelization code	0 to 255
Slot structure	acquisition indicators, empty symbols
PDSCH	Physical Downlink Shared Channel
Symbol rate	15, 30, 60, 120, 240, 480, 960 ksps
Channelization code	depending on symbol rate, 0 to max. 255
Slot structure	data
DL-DPCCH	Dedicated Physical Control Channel
Symbol rate	7.5 ksps, fixed
Channelization code	0 to 511
Slot structure	TPC, pilot
DPCH	Dedicated Physical Channel
Symbol rate	7.5, 15, 30, 60, 120, 240, 480, 960 ksps depending on symbol rate,
Channelization code	0 to max. 511
Slot structure	data 1, TPC, TFCI, data 2, pilot
Physical channels in uplink	
PRACH	Physical Random Access Channel
Symbol rate	15, 30, 60, 120 ksps
Frame structure	preamble(s), message part consisting of data and control section
Preamble part power	–60 dB to 0 dB
Data part power	–60 dB to 0 dB
Control part power	–60 dB to 0 dB
Preamble repetition	1 to 10
Signature	0 to 15
Access slot	0 to 14
Message part length	1 or 2 frames
TFCI	0 to 1023
User data	PRBS: PN9, PN11, PN15, PN16 all 0, all 1 and bit pattern (max. length 16 bit)

PCPCH	Physical Common Packet Channel
Symbol rate	15, 30, 60, 120 ksps
Frame structure	access preamble(s), collision detection preamble, power control preamble, message part consisting of data and control section
Preamble part power	–60 dB to 0 dB
Data part power	–60 dB to 0 dB
Control part power	–60 dB to 0 dB
Preamble power step	0 dB to 10 dB
Shared resource mode	OFF/ON
Preamble repetition	1 to 10
Signature	0 to 15
Access slot	0 to 14
Message part length	1 to 10 frames
Power control preamble length	0 or 8 slots
FBI state	OFF/1 bit/2 bit
FBI pattern	all 0, all 1 and bit pattern (max. 16 bit long)
User data	PRBS. PN9, PN11, PN15, PN16 all 0, all 1 and bit pattern (max. length 16 bit)
DPCCH	Dedicated Physical Control Channel
Symbol rate	15 ksps, fixed
Channelization code	0, fixed
DL–UL timing offset	1024 chips, fixed
FBI state	OFF/1 bit/2 bit
FBI pattern	all 0, all 1 and bit pattern (max. length 16 bit)
TFCI state	OFF/ON
TFCI	0 to 1023
Use TPC for dynamic output	OFF/ON
Power control	If this function is active, the TPC pattern is used to vary the transmit power of the MS code channels versus time
Output power control step	–10 dB to +10 dB
DPDCH	Dedicated Physical Data Channel
Overall symbol rate	overall data rate of all uplink DPDCHs 15, 30, 60, 120, 240, 480, 960, 2 x 960, 3 x 960, 4 x 960, 5 x 960, 6 x 960 ksps
Active DPDCHs	1 to 6, depending on overall symbol rate
Symbol rate	fixed for active DPDCHs, depending on overall symbol rate
Channelization code	fixed for active DPDCHs, depending on overall symbol rate
Channel power	–60 dB to 0 dB for all DPDCHs
User data	PRBS: PN9, PN11, PN15, PN16 all 0, all 1 and bit pattern (max. length 16 bit)

Parameters for each base station (BS)

State	OFF/ON
2nd search code group	0 to 63 (depending on scrambling code)
Scrambling code	0 to 5FFFF hex or off
TFCI state	OFF/ON
TFCI	0 to 1023
TPC pattern readout mode	use of TPC pattern: continuous, single + all 0, single + all 1, single + alternating 01, single + alternating 10
Use TPC for dynamic output power control	OFF/ON If this function is active, the TPC pattern is used to vary the transmit power of the code channels versus time.
Output power control step	–10 dB to +10 dB
Transmit diversity	OFF/antenna 1/antenna 2 If this function is active, the output signal for antenna 1 or antenna 2 can be generated as defined in the standard.

Parameter for each mobile station (MS)

State	OFF/ON
Mode	PRACH only, PCPCH only, DPCCH + DPDCHs
Scrambling code	0 to FF FFFF hex
Scrambling code mode	long, short, off
TPC pattern	all 0, all 1 and bit pattern (max. length 16 bit)
TPC pattern readout mode	use of TPC pattern: continuous, single + all 0, single + all 1, single + alternating 01, single + alternating 10

Parameters for each downlink code channel, independently selectable

State	OFF/ON
Symbol rate	between 7.5 ksps and 960 ksps, depending on type of physical channel
Channelization code	range 0 to max. 511, depending on symbol rate and type of physical channel
Power	–60 dB to 0 dB
User data	PRBS: PN9, PN11, PN15, PN16 all 0, all 1 and bit pattern (max. length 16 bit)
Timing offset	separately adjustable for each code channel 0 to 149 (in units of 256 chips)
Pilot length	2, 4, 8, 16 bit depending on symbol rate
TPC pattern	all 0, all 1 and bit pattern (max. length 16 bit)
Multicode state	OFF/ON

Compressed mode

State	OFF/ON
Compressed mode method	higher layer scheduling, puncturing (downlink only) or SF/2
Downlink frame structure	type A (last pilot) or type B (first TPC, last pilot)
Power offset for compressed slots	automatic or manual in range 0 dB to 10 dB
Number of transmission patterns	1 or 2
Number of transmission gaps per pattern	2
TGSN (Transmission Gap Slot Number) TGL1, TGL2 (Transmission Gap Length 1, 2) TGD1, TGD2 (Transmission Gap Distance 1, 2) TGPL1, TGPL2 (Transmission Gap Pattern Length 1, 2)	user-selectable within the range permitted by the standard; conflicting parameters are displayed and solutions proposed

Assistant functions to facilitate operation

Test models (supplied as example files)	test model 1 with 16/32/64 channels test model 2 test model 3 with 16/32 channels test model 4
Parameterizable predefined settings	Generation of complex signal scenarios in downlink with parameterizable default settings. Selectable parameters: use and symbol rate of special channels (for synchronization of mobile), number and symbol rate of data channels, crest factor: minimal/average/worst
Multichannel edit	Common configuration of data channels of BS channel table. Selectable parameters, partly with start value and step size: range of data channels to be set, symbol rate, channelization code with step size, channel power with step size, data, TPC, timing offset with step size, multicode state, state

Copy BS/MS	Adopting the configuration of a BS for another BS/MS for the definition of multi-BS/MS scenarios or BS signals with more than 128 channels. Parameters: source and destination of copying, channelization code offset for simple definition of BS signals with more than 128 channels and continuous channelization codes
Resolve domain conflicts	Elimination of code channel overlapping in code domain (domain conflicts) occurring in a BS/MS
Graphic displays	
Domain conflicts	Display of domain conflicts (overlapping of code channels in code domain) in the channel table lines concerned The code domain occupied by the code channels involved in the conflict can also be displayed
Code domain	Display of code domain occupied by current BS. Domain areas in which conflicts occur are highlighted. The distribution of code channels in the code domain as well as channel powers are shown qualitatively.
Channel graph	Display of all active channels of a BS versus the channel table index. The powers of the code channels are shown qualitatively
CCDF	Display of complementary cumulative distribution function of current signal This function gives the probability of the magnitudes of complex I/Q samples exceeding a predefined threshold. Together with the current CCDF, the CCDFs of the two 3GPP signals last generated can be displayed to observe the effect of parameter changes The crest factor of the signal can be seen in the CCDF
Constellation diagram	Display of constellation diagram versus I/Q samples of current 3GPP signal This diagram allows qualitative assessment of channel configuration, channel power ratios, and the effect of parameters such as data and data offset

Simulation of signals to time division duplex wideband CDMA standard according to version 4.1.0 of the 3GPP Technical Specification TS 25.221, TS 25.223, available as Software Option AMIQK13 of the AMIQ or Software Option SMIQK13 and Arbitrary Waveform Generator Option SMIQB60 of the SMIQ

General settings	
Chip rate	
Standard	3.84 Mcps
Range	AMIQ: 10 cps to max. 100 Mcps SMIQ (B60): 1 kcps to max. 40 Mcps
Mode	downlink only: the base station components of a cell are active uplink only: the mobile station components of a cell are active downlink and uplink: both the base station and the mobile station component of a cell are active
Sequence length	entry in slots (0.667 ms each) or frames (10 ms each), max. length depending on oversampling AMIQ03 (for oversampling 4): 1 to 26 frames AMIQ04 (for oversampling 4): 1 to 104 frames SMIQB60 (for oversampling 2 in WinIQSIM™ (oversampling >4 as a result of hardware oversampling in the SMIQ): 1 to 6 frames
Baseband filter	
Standard	root raised cosine filter, roll off = 0.22
Other filters	same as in single-carrier system
Cells	simulation of up to 4 cells, each comprising 15 slots
Clipping level	Setting of clipping value relative to highest peak in percent. Clipping takes place prior to baseband filtering. Either scalar mode or vector mode can be selected. Clipping reduces the crest factor. The range is 1% to 100%.
Parameter for each cell	
State	OFF/ON
Frame structure	The link direction (uplink or downlink) can be set independently for each of the 15 slots of the frame. All single- and multi-switching point configurations can be simulated
Scrambling code	0 to 127 scrambling code can be disabled for testing
Code group	automatic selection depending on scrambling code 0 to 31
Midamble allocation method	default common equal to scrambling code
Guard field power state	OFF (according to standard)/ON
Parameters for each downlink slot	
State	OFF/ON
Slot mode	downlink dedicated: simulation of up to 16 DPCHs and max. 6 special channels
Burst type	1 and 2
SCH assoc. t_offset	automatic selection depending on scrambling code 0 to 31
SCH code allocation	cases 1 and 2 to TS 25.223
Page indicator length	2, 4, 8
Parameters for each uplink slot	
Slot mode	uplink dedicated: simulation of up to 16 DPCHs and 1 special channel PRACH: simulation of one Physical Random Access Channels
TPC pattern readout mode	application mode for TPC pattern continuous, single + all 0, single + all 1, single + alt. 01, single + alt. 10
Burst type	1, 2 and 3
Parameters in uplink PRACH mode	
Burst type	3
Start frame	selection of first frame in which PRACH is sent 0 to 10
PRACH length	length of PRACH message part 1 to 10 frames
User	index of user to which PRACH is assigned
Midamble and midamble shift	display of midamble used and of midamble time shift, depending on midamble allocation method and user
Spreading factor	8 and 16

Spreading code	spreading code of channel, range depending on spreading factor 1 to max. 16
Power	–60 dB to 0 dB
Physical channels	
Data	4 different data sources, 3 same as in single-carrier system, another PBRS source with differing start values for different code channels
Downlink	Primary Common Control Physical Channel (P-CCPCH) Secondary Common Control Physical Channel (S-CCPCH) Primary Sync Channel (P-SCH) Secondary Sync Channel (S-SCH) Physical Downlink Shared Channel (PDSCH) Page Indicator Channel (PICH) Dedicated Physical Channel (DPCH)
Uplink	Physical Random Access Channel (PRACH) Physical Uplink Shared Channel (PUSCH) Dedicated Physical Channel (DPCH)
Parameters independently selectable for each code channel	
State	OFF/ON
User	1 to 16 with burst types 1 and 3 1 to 6 with burst type 2
Spreading factor	depending on channel type and link direction 1, 2, 4, 8, 16
Spreading code	depending on channel type and spreading factor 1 to max. 16
Midamble and midamble shift	display of midamble used and of midamble time shift, depending on midamble allocation method and user
TFCI/TPC combination	combination of TFCI and TPC fields, TPC in uplink only, uplink: TFCI 0 | TPC 0, TFCI 0 | TPC 2, TFCI 4 | TPC 2, TFCI 8 | TPC 2, TFCI 16 | TPC 2, TFCI 32 | TPC 2 downlink: TFCI 0, TFCI 4, TFCI 8, TFCI 16, TFCI 32
TFCI	transport format combination indicator 0 to 1023
TPC pattern	bit pattern (max. length 16 bit) as a data source for the TPC field of the channel, in uplink only
Power	–60 dB to 0 dB
Data	4 different data sources, 3 same as in single-carrier system, another PBRS source with differing start values for different code channels
Assistant functions to facilitate operation	
Copy cell	Adopting the configuration of a cell for another cell to define multicell scenarios. Parameters: source and destination of copying
Resolve domain conflicts	Elimination of code channel overlapping in code domain occurring in a slot (domain conflicts).
Graphic displays	
Domain conflicts	Display of domain conflicts (overlapping of code channels in code domain) in the channel table lines concerned. The code domain occupied by the code channels involved in the conflict can also be displayed.
Code domain	Graphic display of code domain occupied by active slot. Domain areas in which conflicts occur are highlighted. Code channel distribution in the code domain and channel powers are displayed.
Channel graph	Display of all active channels of a slot versus the channel table index. The powers of the individual code channels are indicated.
CCDF	Display of the complementary cumulative distribution function of the current signal. This function gives the probability of the magnitudes of the complex I/Q samples exceeding a predefined threshold. Together with the current CCDF, the CCDFs of any number of 3GPP TDD signals generated last can be displayed to observe the effect of parameter changes. The crest factor of the signal can be seen in the CCDF.
Constellation diagram	Display of constellation diagram versus I/Q samples of the current 3GPP TDD signal. This diagram allows qualitative assessment of channel configuration, channel power ratios, and effect of TDD system parameters.

TD-SCDMA	Simulation of signals according to time division synchronous CDMA standard of China Wireless Telecommunication Standard Group (CWTS), available as Software Option AMIQK14 of the AMIQ or Software Option SMIQK14 and Arbitrary Waveform Generator Option SMIQB60 of the SMIQ
General settings	
Chip rate	
Standard	1.28 Mcps
Range	AMIQ: 10 cps to max. 100 Mcps SMIQ (B60): 1 kcps to max. 40 Mcps
Mode	downlink only: the base station components of a cell are active uplink only: the mobile station components of a cell are active downlink and uplink: both the base station and the mobile station component of a cell are active
Sequence length	entry in frames (5 ms each), max. length depending on oversampling and AMIQ03 (for oversampling 4): 1 to 156 frames AMIQ04 (for oversampling 4): 1 to 625 frames SMIQ (B60): (for oversampling 2 in WinIQSIM™ (oversampling >4 as a result of hardware oversampling in SMIQ)): 1 to 40 frames
Baseband filter	
Standard	root raised cosine filter, roll off = 0.22
Other filters	same as in single-carrier system
Cells	simulation of up to 4 cells, each comprising 7 traffic slots and 3 special slots
Clipping level	Setting of clipping value relative to highest peak in percent. Clipping takes place prior to baseband filtering. Either scalar mode or vector mode can be selected. Clipping reduces the crest factor. The range is 1% to 100%.

Parameters for each cell

State	OFF/ON
Frame structure	total of 7 traffic slots, slot 0 always reserved for downlink, slot 1 to switching point reserved for uplink, other slots reserved for downlink; special slots between slots 0 and 1: Downlink Pilot Slot (DwPTS), Guard Period (GP) and Uplink Pilot Slot (UpPTS)
Scrambling code	0 to 127 scrambling code can be disabled for testing
SYNC code	automatic selection depending on scrambling code 0 to 31
Switching point	switchover between uplink and downlink slots 1 to 6
Layer 1 control fields	can be enabled and disabled to simulate burst types 1 and 2
DwPTS power	–60 dB to 0 dB

Parameters for each downlink slot

State	OFF/ON
Slot mode	downlink dedicated: simulation of up to 16 DPCHs and max. 5 special channels
TPC pattern readout mode	application mode for TPC pattern continuous, single + hold 01, single + hold 10, single + all up, single + all down
Sync shift repetition M	number of frames to which sync shift bits are distributed 1 to 500
Stealing flag	value of the two stealing bits 0 to 3

Parameters for each uplink slot

Slot mode	uplink dedicated: simulation of up to 16 DPCHs PRACH: simulation of one Physical Random Access Channels
TPC pattern readout mode	application mode for TPC pattern continuous, single + hold 01, single + hold 10, single + all up, single + all down
Sync shift repetition	number of frames to which sync shift bits are distributed 1 to 500
Stealing flag	value of the two stealing bits 0 to 3

Parameters in uplink PRACH mode

SYNC 1	SYNC 1 code 0 to 7
UpPTS start frame	selection of first frame in which UpPTS is sent 1 to 6
UpPTS repe[illegible]	number of UpPTS repetitions 1 to 10
PRACH length	length of PRACH message part 1 to 10 frames
Gross data rate	17.6 kbps, 35.2 kbps
Spreadi[illegible]	depending on gross data rate 0 to max. 15
Sync shift patt[illegible]	bit pattern (max. length 16 bit) as a data source for the sync shift field of the channel
[illegible]	bit pattern (max. length 16 bit) as a data source for the TPC field of the channel
[illegible]	–60 dB to 0 dB
[illegible]	4 different data sources, 3 same as in single-carrier system, another PRBS source with differing start values for different code channels

Physical channels

Downlink	Primary Common Control Physical Channel (P-CCPCH) Secondary Common Control Physical Channel (S-CCPCH) Physical Forward Access Channel (F-FACH) Downlink Pilot Time Slot (DwPTS) Dedicated Physical Channel (DPCH)
Uplink	Physical Random Access Channel (PRACH) Uplink Pilot Time Slot (UpPTS) Dedicated Physical Channel (DPCH)

Parameters independently selectable for each code channel

State	OFF/ON
Gross data rate	depending on channel type 17.6 kbps, 35.2 kbps, 70.4 kbps, 140.8 kbps, 281.6 kbps (spreading factors 1, 2, 4, 8, 16)
Spreading code	depending on channel type and gross data rate 0 to max. 15
Midamble shift	time shift of midamble in chips: 0 to 120, step width 8 chips
Power	–60 dB to 0 dB
Data	4 different data sources, 3 same as in single-carrier system, another PRBS source with differing start values for different code channels
Sync shift pattern	bit pattern (max. length 16 bit) as a data source for the sync shift field of the channel
TPC pattern	bit pattern (max. length 16 bit) as a data source for the TPC field of the channel

Assistant functions to facilitate operation

Predefined settings	Generation of complex signal scenarios with parameterizable default settings. Selectable parameters: use of special channels (P-CCPCH) number and gross data rate of data channels crest factor: minimal/average/worst
Copy cell	Adopting the configuration of a cell for another cell for the definition of multicell scenarios Parameters: source and destination of copying
Resolve domain conflicts	Elimination of code channel overlapping in code domain occurring in a slot (domain conflicts).

Graphic displays

Domain conflicts	Display of domain conflicts (overlapping of code channels in code domain) in the channel table lines concerned. The code domain occupied by the code channels involved in the conflict can also be displayed.
Code domain	Graphic display of code domain occupied by active slot. Domain areas in which conflicts occur are highlighted. Code channel distribution in the code domain and channel powers are displayed.
Channel graph	Display of all active channels of a slot versus the channel table index. The powers of the individual code channels are indicated.

CCDF	Display of the complementary cumulative distribution function of the current signal. This function gives the probability of the magnitudes of the complex I/Q samples exceeding a predefined threshold. Together with the current CCDF, the CCDFs of any number of TD-SCDMA signals generated last can be displayed to observe the effect of parameter changes. The crest factor of the signal can be seen in the CCDF
Constellation diagram	Display of constellation diagram versus I/Q samples of the current TD-SCDMA signal. This diagram allows qualitative assessment of channel configuration, channel power ratios, and effect of TD-SCDMA system parameters.

Simulation of CDMA signals to North American standard IS-95 A, available as Software Option AMIQK11 of the AMIQ or Software Option SMIQK11 in conjunction with the Arbitrary Waveform Generator Option SMIQB60 of the SMIQ

General settings

Chip rate	
Standard	1.2288 Mcps
Range	AMIQ: 10 cps to 100 Mcps SMIQB60: 1 kcps to 40 Mcps
Link direction	forward link and reverse link
Sequence length	entry in symbols (1536 symbols correspond to frame of 80 ms), max. length depending on oversampling AMIQ03 (for oversampling 4): 1 to 10 frames AMIQ04 (for oversampling 4): 1 to 40 frames SMIQB60 (for oversampling 2 in WinIQSIM™, and oversampling >4 in SMIQ due to hardware oversampling): 1 to 2 frames
Baseband filter	
Standard	CDMA2000 1X (corresponds to IS-95 filter)
Other filters	same as with single-carrier system
Clipping level	Setting of clipping value relative to highest peak in percent. Clipping takes place prior to baseband filtering and reduces the crest factor. The range is 1% to 100 %.
Parameters for each base station	PN offset 0 to 511
Parameters for each code channel	state on/off, power, data, long code mask
Physical channels in forward link	
Pilot	
Paging	parameters: data, long code mask with PCN and pilot PN field
Sync	parameter: data
Traffic	parameters: data, long code mask with permuted ESN field
Physical channels in reverse link	
Access	parameters: data, long code mask with ACN, PCN, base ID and pilot PN field
Traffic	parameters: data, long code mask with permuted ESN field
Channel power	–40 dB to 0 dB
Modulation data	4 different data sources, 3 same as with single-carrier system, another PRBS source with differing start values for different code channels
Baseband filtering	same as with single-carrier system
Simulation of impairments and transmission characteristics	same as with single-carrier system
Smoothing	same as with single-carrier system
Graphic output	same as with single-carrier system

CCDF	Display of complementary cumulative distribution function of current signal. This function gives the probability of the magnitudes of complex I/Q samples exceeding a predefined threshold. Together with the current CCDF, the CCDFs of any number of IS-95 signals last generated can be displayed to observe the effect of parameter changes. The crest factor of the signal can be seen in the CCDF.
ACP calculation	Calculation of adjacent-channel power in spectrum display (ACP up, low and ACP up 1st alt, low 1st alt)
IF signal generation	Modulation of calculated I/Q signal to intermediate frequency in the range 0.01 MHz to 25 MHz (output to I channel of AMIQ)

Simulation of CDMA signals to North American standard IS-2000, available as Software Option AMIQK12 of the AMIQ or Software Option SMIQK12 in conjunction with the Arbitrary Waveform Generator Option SMIQB60 of the SMIQ

General settings

Chip rate	
Standard	1.2288 Mcps (1X), 3.6864 Mcps (3X)
Range	AMIQ: 10 cps to 100 Mcps SMIQB60: 1 kcps to 40 Mcps
Carrier spacing	
Standard	1.25 MHz
Variable	AMIQ: 0 to 10 MHz SMIQB60: 0 to 2 MHz
Modes	1X Direct Spread 3X Direct Spread 3X Multi Carrier (forward link only)
Link direction	forward link and reverse link
Sequence length	entry in frames of 80 ms, max. length depending on chip rate, mode and oversampling AMIQ03 (for oversampling 4): 1 to 10 frames at 1.2288 Mcps (1X) 1 to 6 frames at 3.6864 Mcps (3X) Multi Carrier 1 to 3 frames at 3.6864 Mcps (3X) Direct Spread AMIQ04 (for oversampling 4): 1 to 40 frames at 1.2288 Mcps (1X) 1 to 26 frames at 3.6864 Mcps (3X) Multi Carrier 1 to 13 frames at 3.6864 Mcps (3X) Direct Spread SMIQB60 (for oversampling 2 in WinIQSIM™, and oversampling >4 in SMIQ due to hardware oversampling): 1 to 2 frames at 1.2288 Mcps (1X) 1 frame at 3.6864 Mcps (3X) Multi Carrier 1 frame at 3.6864 Mcps (3X) Direct Spread
Baseband filter	
Standard	CDMA2000 1X CDMA2000 3X Direct Spread
Other filters	same as with single-carrier system
Code channels	
Forward link	4 base stations with max. 91 code channels each (depending on radio configuration)
Reverse link	4 mobile stations with max. 13 code channels each (depending on radio configuration)
Clipping level	Setting of clipping value relative to highest peak in percent. Clipping takes place prior to baseband filtering and reduces the crest factor. The range is 1% to 100 %.

Parameters for each base station (BS)

State	off/on
Radio configuration	
Chip rate 1.2288 Mcps (1X)	RC 1 to RC 5
Chip rate 3.6864 Mcps (3X)	RC 6 to RC 9
PN offset	0 to 511
Quasi-orthogonal Walsh sets	set 1 to set 3
Channel coding	All levels of channel coding provided by IS-2000 (e.g. frame quality indicator, convolutional encoder, symbol puncture and interleaver) are available. All combinations of frame lengths and data rates are supported. Four modes are available: – off: channel coding off – complete: complete channel coding on – without interleaving: channel coding on, but without interleaver – interleaving only: channel coding off, interleaver active only
Transmit diversity (OTD)	off / antenna 1 / antenna 2 If this function is active, the output signal for antenna 1 or antenna 2 can be generated as defined in the standard.
Use TPC for dynamic output power control	off/on If this function is active, the TPC pattern is used to vary the transmit power of the code channels versus time.
Output power control step	–10 dB to +10 dB

Parameters for each mobile station (MS)

State	off/on
Radio configuration	
Chip rate 1.2288 Mcps (1X)	RC 1 to RC 4
Chip rate 3.6864 Mcps (3X)	RC 5 to RC 6
Channel coding	All levels of channel coding provided by IS-2000 (e.g. frame quality indicator, convolutional encoder, symbol puncture and interleaver) are available. All combinations of frame lengths and data rates are supported. Four modes are available – off: channel coding off – complete: complete channel coding on – without interleaving: channel coding on, but without interleaver – interleaving only: channel coding off, interleaver active only
Use TPC for dynamic output power control	off/on If this function is active, the TPC pattern (selectable bit pattern, max. length 16 bit) is used to vary the transmit power of the code channels versus time.
Output power control step	–10 dB to +10 dB

Channel types

Forward link	Special channels: – Forward Pilot (F-PICH) – Sync (F-SYNC) – Paging (F-PCH) – Transmit Diversity Pilot (F-TDPICH) – Auxiliary Pilot (F-APICH) – Auxiliary Transmit Diversity Pilot (F-ATDPCH) – Broadcast (F-BCH) – Quick Paging (F-QPCH) – Common Power Control (F-CPCCH) – Common Assignment (F-CACH) – Forward Common Control (F-CCCH) Traffic channels: – Forward Dedicated Control (F-DCCH) – Forward Fundamental (F-FCH) – Forward Supplemental (F-SCH)
Reverse link	Special channels: – Reverse Pilot (R-PICH) – Access (R-ACH) – Enhanced Access (R-EACH) – Reverse Common Control (R-CCCH) – Reverse Dedicated Control (R-DCCH) Traffic channels: – Reverse Fundamental (R-FCH) – Reverse Supplemental Code (R-SCCH) – Reverse Supplemental 1 (R-S1CH) – Reverse Supplemental 2 (R-S2CH)

Parameters independently selectable for each forward link code channel

State	off/on
Frame length	depending on channel type and radio configuration 5 ms, 10 ms, 20 ms, 40 ms, 80 ms
Data rate	depending on channel type and radio configuration: 1.2 kbps to max. 1036.8 kbps
Walsh code	depending on channel type and radio configuration: 0 to max. 255
Quasi-orthogonal code	off/on
Long code mask	0 to 3FF FFFF FFFF hex
Power	–60 dB to 0 dB
Data	4 different data sources, 3 same as with single-carrier system, another PRBS source with differing start values for different code channels
TPC pattern	bit pattern (max. length 16 bit)

Parameters independently selectable for each reverse link code channel

State	off/on
Frame length	depending on channel type and radio configuration 5 ms, 10 ms, 20 ms, 40 ms, 80 ms
Data rate	depending on channel type and radio configuration 1.2 kbps to max. 1036.8 kbps
Long code mask	0 to 3FF FFFF FFFF hex
Power	–60 dB to 0 dB
Data	4 different data sources, 3 same as with single-carrier system, another PRBS source with differing start values for different code channels

Assistant functions to facilitate operation

Parameterizable predefined settings (forward link only)	Generation of complex signal scenarios with parameterizable default settings. Selectable parameters: – use of special channels (F-PICH, F-SYNC, number of F-QPCHs) – number, frame length and data rate of data channels – crest factor: minimal/average/worst
Multichannel edit (forward link only)	Common configuration of data channels of BS channel table. Selectable parameters, partly with start value and step size: – range of data channels to be set – frame length – data rate – Walsh code with step width – state of quasi-orthogonal Walsh set – channel power with step size – data – TPC – state
Copy BS/MS	Adopting the configuration of a BS/MS for another BS/MS to define multi-BS/MS scenarios. Parameters: – source and destination of copying – Walsh code offset (forward link)

Graphic displays

Domain conflicts (forward link only)	Display of domain conflicts (overlapping of code channels in code domain) in the channel table lines concerned. The code domain occupied by the code channels involved in the conflict can also be displayed.
Code Domain (forward link only)	Display of code domain occupied by current BS. Domain areas in which conflicts occur are highlighted. The distribution of code channels in the code domain as well as channel powers are displayed.
Channel graph	Display of all active channels of a BS/MS versus the channel table index. The powers of the code channels are shown.
CCDF	Display of complementary cumulative distribution function of current signal. This function gives the probability of the magnitudes of complex I/Q samples exceeding a predefined threshold. Together with the current CCDF, the CCDFs of any number of CDMA2000 signals last generated can be displayed to observe the effect of parameter changes. The crest factor of the signal can be seen in the CCDF
Constellation diagram	Display of constellation diagram versus I/Q samples of current CDMA signal. This diagram allows qualitative assessment of channel configuration, channel power ratios, and effect of selected Walsh codes

Simulation of signals to the Wireless LAN standard IEEE 802.11b, available as Software Option AMIQK16 of the AMIQ or
Software Option SMIQK16 in conjunction with the Arbitrary Waveform Generator Option SMIQB60 of the SMIQ

General settings

Chip rate	
Standard	11 Mcps
Range	AMIQ: 10 cps to max. 100 Mcps SMIQ (B60): 1 kcps to max. 40 Mcps
Simulation mode	framed mode: generation of a sequence of data packets with the frame structure defined by the standard, interrupted by an idle time unframed mode: generation of a non-packet-oriented signal without frame structure, with the modulation modes and data rates defined by the 802.11b standard
User data	same as with single-carrier system
Baseband filter	
Standard	Gaussian filter, BT = 0.3
Other filters	same as with single-carrier system

Parameters in framed mode

Idle time	time between two successive packets (PPDUs) in µs; range 0 µs to 10.000 µs
Number of packets	number of data packets to be generated; the minimum number of packets is 1; the maximum number depends on the packet length, idle time and oversampling
PLCP preamble and header format	long PLCP and short PLCP
PSDU bit rate	1 Mbps, 2 Mbps, 5.5 Mbps and 11 Mbps
PSDU modulation	DBPSK, DQPSK, CCK and PBCC (depending on PSDU bit rate)
PSDU data length	length of user data field in bytes of the packet to be transferred, range 0 bytes to 2312 bytes
Scrambling	activating or deactivating data packet scrambling
MAC header	activating and configuring the MAC header with the parameters Frame Control, Duration/ID, Address 1-4 and Sequence Control
Frame check sequence	activating or deactivating a 32-bit (4-byte) check sum for protecting the MAC header and the user data proper (frame body)
Power time template	automatic configuration of power ramping at the beginning and end of the data packets with shiftable start points of the ramps relative to the data packet

Parameters in unframed mode

PSDU bit rate	1 Mbps, 2 Mbps, 5.5 Mbps and 11 Mbps
PSDU modulation	DBPSK, DQPSK, CCK and PBCC (depending on PSDU bit rate)
Sequence length	length of signal to be generated in bytes, maximum length depending on oversampling
Scrambling	activating or deactivating scrambling

Import of I/Q data from other applications via a dynamic data exchange (DDE) interface or via TCP/IP ; further processing in WinIQSIM™, e.g. baseband filtering or superposition of impairments

Baseband filtering	same as with single-carrier system
Sequence length	AMIQ03: 1 sample to max. 4 Msamples AMIQ04: 1 sample to max. 16 Msamples SMIQB60: 1 sample to max. 524,216 sample
Simulation of impairments and transfer characteristics	same as with single-carrier system
Smoothing	same as with single-carrier system
Graphic output	same as with single-carrier system
ACP calculation	calculation of adjacent-channel power in spectrum display (ACP up, low and ACP up 1st alt, low 1st alt)
IF signal generation	modulation of calculated I/Q signal to IF in the range 0.01 MHz to 25 MHz (output to I channel of AMIQ)

Waveform transmission to AMIQ	interfaces: IEC/IEEE bus (GPIB), RS-232, floppy; conversion of I/Q signal to 14-bit AMIQ format: user-selectable clipping level (over- and underranging possible)
Remote control of AMIQ	download and starting of waveforms, hardware configuration, alignment and fine adjustment, file management, BER test
For data transfer	IEC/IEEE bus (GPIB): card (from National Instruments) with drivers, IEC/IEEE-bus cable; RS-232: null-modem cable
System requirements	PC compatible to industry standard, CPU clock min. 100 MHz, Windows95/98 with 32 Mbyte RAM or WindowsNT with 48 Mbyte RAM recommended, at least 50 Mbyte hard disk memory, mouse, monitor 1024 x 768 pixels with 256 colours recommended

I/Q Modulation Generator	AMIQ	
4 Msamples		1110 2003 03
16 Msamples		1110 2003 04
Internal Arbitrary Waveform Generator in the SMIQ	SMIQB60	1136 4390 02
Digital Standard		
IS-95	AMIQK11	1122 2003 02
	SMIQK11	1105 0287 02
CDMA2000	AMIQK12	1122 2503 02
	SMIQK12	1105 0435 02
WCDMA TDD Mode (3GPP)	AMIQK13	1122 2603 02
	SMIQK13	1105 1231 02
TD-SCDMA	AMIQK14	1122 2703 02
	SMIQK14	1105 1383 02
IEEE 802 11b	AMIQK16	1122 2903 02
	SMIQK16	1154 7700 02
OFDM Signal Generation	AMIQK15	1122 2803 02
	SMIQK15	1105.1531 02

Certified Environmental System
ISO 14001

Certified Quality System
ISO 9001

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1 Introduction

The number of digital modulation methods based on I/Q modulation in mobile communications systems has dramatically increased in the past few years. Examples of these methods are the global GSM standard or the American mobile radio standard NADC. More and more time is required for generating test signals for these systems since getting familiar with the respective standard alone is very time-consuming.

While a 3rd generation of mobile radio standards (UMTS) is being defined, the demand for developing new methods for modulation and channel access is greater than ever.

I/Q modulation is therefore gaining importance for the development of such modulation methods. Modulation Generator AMIQ and Simulation Software WinIQSIM open up new dimensions for the generation of I/Q signals.

WinIQSIM, successor of the well-proven IQSIM, is a Windows software permitting calculation of I and Q baseband signals at the IF. Among its functions are single-carrier modulation, the generation of multicarrier and W-CDMA signals and a convenient data editor for setting up TDMA frame configurations. All modulation parameters and impairments can be simulated for single-carrier, multicarrier or W-CDMA signals.
All in all, WinIQSIM is an indispensable tool for anyone engaged in state-of-the-art digital modulation.

WinIQSIM can do much more than the simple and fast generation of digitally modulated signals. A central display and control element, the so-called block diagram representing the transmission model of signal generation, gives the user a clear overview of the signal generation process. All components contained in the block diagram from data source and modulation to the superposition of impairments and simulation of the transmission channel illustrate the structure and procedure of internal signal generation.

The whole process of signal configuration can be controlled via the block diagram. The current status of signal configuration and active interfering components can be seen at a glance.

A status line above the main window informs on current signal parameters like type of modulation, coding, symbol rate, filter and window function as well as on oversampling. The parameters for basically all types of modulation can of course be set independently and as required by the user.

Setting windows can be arranged next to each other so that an optimal user interface can be created for the application on hand.

Comprehensive graphics display modes in the time and frequency domain (eg i(t) and q(t), vector diagram, spectrum) permit simulation and analysis of characteristics as early as in the design phase of new digital communications systems.

WinIQSIM, AMIQ and SMIQ - an ideal combination

The system comprising SMIQ as a vector signal generator, AMIQ as a source for baseband signals and WinIQSIM for configuring signal data, makes for a convenient generation of all kinds of complex, digitally modulated communications signals.

With WinIQSIM, computed signals can be loaded onto the AMIQ hard disk, floppy or directly into the output memory of AMIQ via the IEC/IEEE bus or the RS-232 interface.
In addition, all AMIQ functions can be set under WinIQSIM via a separate menu. The I/Q signals generated by AMIQ control the I/Q modulator of SMIQ.

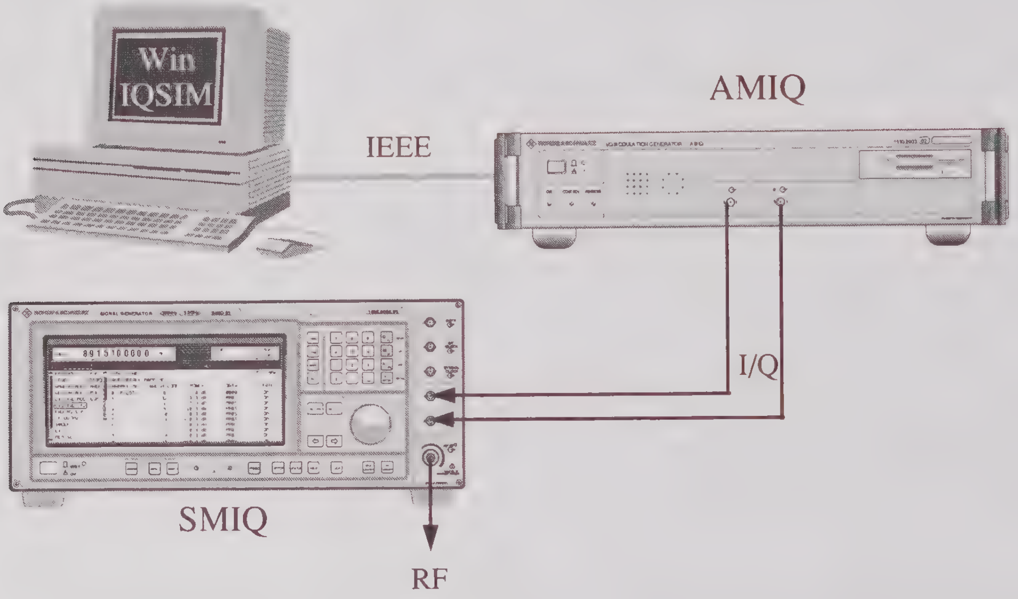


Fig. 1-1 Interplay of WinIQSIM, AMIQ and SMIQ

2 Putting into Operation

2.1 Requirements

2.1.1 Software Requirements

Windows 95/98 or Windows NT (version 4.0 or higher),
GPIB (IEC)-bus driver for Windows from National Instruments.

2.1.2 Hardware

- CPU: at least 486, Pentium or compatible as from 100 MHz recommended,
- RAM: at least 32 Mbyte (Windows NT at least 48 Mbytes),
- GPIB (IEC/IEEE)-bus card from National Instruments,
- VGA colour display, minimum resolution at least 800*600 pixels, 1024*768 recommended, small fonts.

2.2 General on Installation

During the installation the user may change two path names, the directory name for the installation of WinIQSIM (default: c:\winiqsim) and the path name for LabWindows/CVI RunTime Engine. This software is required for WinIQSIM but need not be copied again if it is already installed.

To allow WinIQSIM to address AMIQ via the GPIB (IEC/IEEE) bus, to load curves or operate the instrument, the hardware and software from National Instruments must be fitted and loaded. Refer to the supplied documents for further information.

2.3 Installation/Deinstallation on Windows 95/98/NT

Installation on CD
After inserting the WinIQSIM CD, a file is displayed allowing you to install the WinIQSIM software on your computer. The Setup.exe program which is called up automatically under WinIQSIM\Install guides you through the following.

If this AutoRun function is deactivated when changing a CD on your computer, start the Start.pdf program by clicking

- Start → Run... in the taskbar or by a
- double-click on Start.pdf on your workstation → CD-ROM drive.

If Windows then displays the "Open With" window, the Adobe Acrobat Reader program for reading the Start.pdf file is not yet installed. In this case, start the Setup.exe program in the Acrobat_Reader directory.

Installation on floppy
If the computer does not have a CD-ROM drive, the required data can also be copied on several floppies. Copy the following files on floppy 1 from the WinIQSIM\Install directory:

- Setup.exe
- WinIQSIM.001
- History.txt
- Readme<nn>.txt.

File WinIQSIM.002 is copied on floppy2,
WinIQSIM.003 on floppy3 ,.
WinIQSIM.004 on floppy4 and so on.

Then insert floppy 1 into the drive and start the **setup.exe** program by clicking

- Start → Run... in the taskbar or by
- double-click on setup32.exe on your workstation → 3 ½ " floppy (A:).

The icon for the deinstallation of the WinIQSIM program is part of the WinIQSIM program group. The directory tree is not cleared when it contains user files.

Note: *Problems that may occur on your Win95 computer:*

Error scenario:
AMIQ cannot be addressed via the IEC/IEEE bus. The National Instruments card drivers seem to be loaded correctly. ***Error cause****:*
Use of 16-bit National Instruments card drivers as used with Windows 3.1 prior to the introduction of Win95. These drivers also run under Win95 (since Win95 is compatible with Win3.1), but WinIQSIM cannot use them. ***Error elimination****:*
*Get (Internet: http:// www.natinst.com) and load preferably the latest drivers (version 1.3 at present) from NI for Win95. The old 16-bit drivers from NI are often still used when a PC is upgraded from Win3.1 to Win95. They may be recognized by the date of the *.dll files. If they have been generated prior to Sept.95 (when Win95 came on the market), they are part of the old version. We were unable to find a version number, only in the readme.txt we found version 1.0. In order to load the 32-bit drivers, the old 16-bit drivers have to be eliminated first, which is a bit laborious since "uninstall" is not provided by NI. The file for the NI software (typ. AT-GPIB) has to be deleted, the program group has to be deleted from the taskbar and the entry nivgpibd.386 from the system.ini file.*

3 Brief Introduction

The following sections give a brief introduction to the WinIQSIM program. Only main functions will be described. A detailed description of the functions can be found in the respective section in chapter 5.

After an overview of the operating concept, menus and the associated toolbar, the main steps required for generating a modulated single-carrier signal are described from selecting the data source to signal transmission to AMIQ. The steps for generating a multicarrier signal and 3GPP CDMA signals follow the same principle and are described in the respective sections of chapter 5.

3.1 General on Operating Concept

Before describing the operating steps, some basic information will be given on the WinIQSIM operating concept.

The main or system panel serves as a workspace (user interface). All other panels are child panels of this window. They can be arranged on the main panel as required. Most of the operating and setting windows are not modal windows. In other words, in the case of non-modal windows several setting panels can be displayed next to each other and settings made alternately. All settings made in non-modal windows are immediately executed and need not be confirmed with OK or aborted with Cancel. The respective window may remain open.

When WinIQSIM is started, the operating status of the last session is restored. All windows of the last session and settings required for defining an I/Q signal are restored.

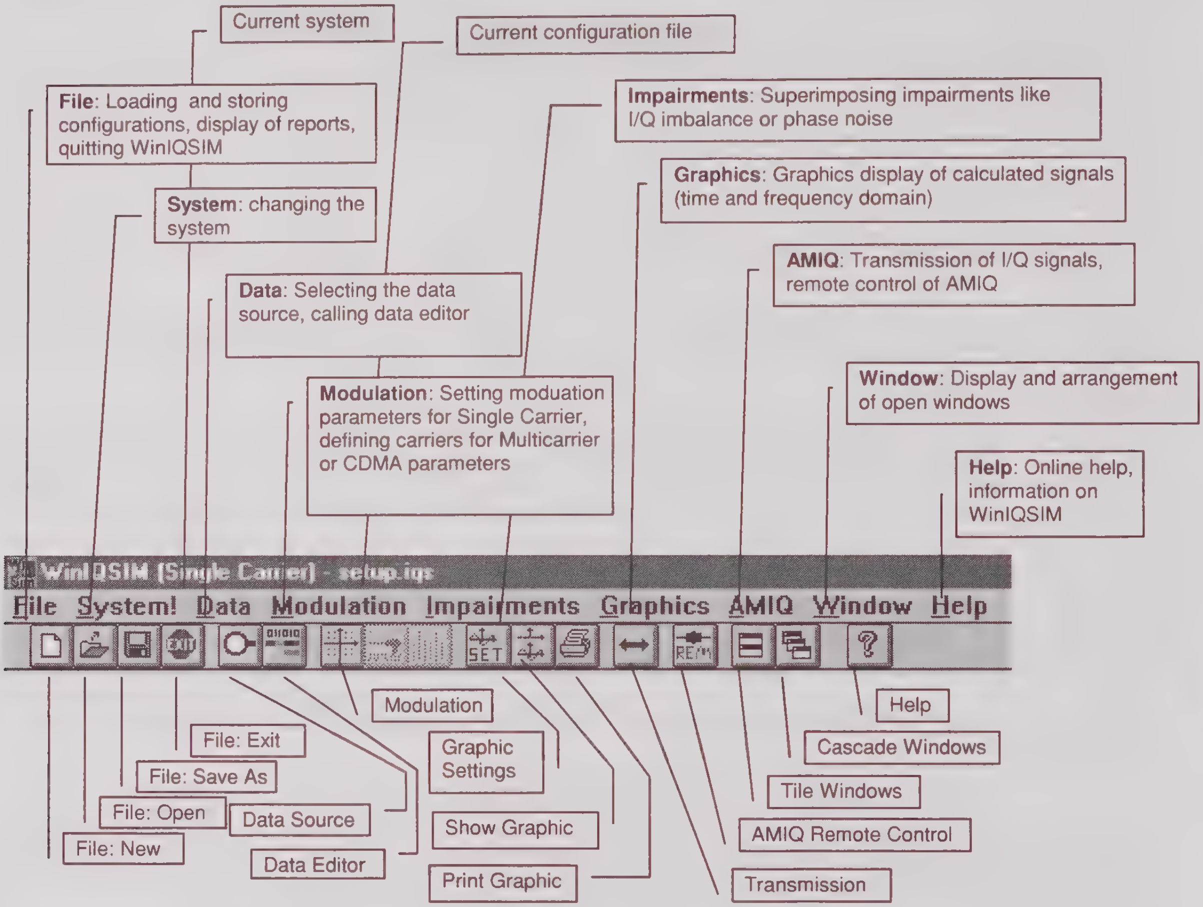
The complete program setup (including panel positions) can also be stored by the user under the menu item File:Save As.

An **OK** button and a **Cancel** button are provided at the lower edge of each panel. Pressing the OK button closes the panel. Since all settings made in this panel are immediately executed, no other actions are required. Pressing the Cancel button also closes the panel but all settings made since the panel was called are rejected. The status of the panel before the call is restored.
The **Esc** key may be used in all panels instead of the Cancel or Close button.

WinIQSIM includes a context-sensitive online help function.

3.2 Operating Menu and Toolbar

The drawing below gives an overview of the operating menu and of the toolbar in the main WinIQSIM window.



File: Loading and storing configurations, display of reports, quitting WinIQSIM

System: changing the system

Data: Selecting the data source, calling data editor

Modulation: Setting moduation parameters for Single Carrier, defining carriers for Multicarrier or CDMA parameters

Impairments: Superimposing impairments like I/Q imbalance or phase noise

Graphics: Graphics display of calculated signals (time and frequency domain)

AMIQ: Transmission of I/Q signals, remote control of AMIQ

Window: Display and arrangement of open windows

Help: Online help, information on WinIQSIM

Fig. 3-1 Operating menu and toolbar

The currently set main parameters are displayed in the status line depending on the selected system.

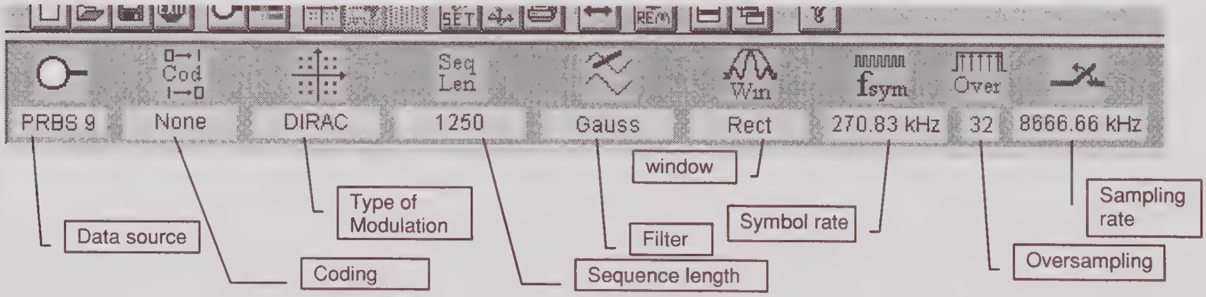


Fig. 3-2 Status line

3.3 Block Diagram

The block diagram is an essential part of each main system panel. The block diagram displays the used transmission model. It illustrates the signal flow and allows simple control and program operation.

There are only slight differences between the block diagrams of the single-carrier, multicarrier and 3GPP W-CDMA systems. Function and meaning of the block diagram for the program run is the same for all systems.

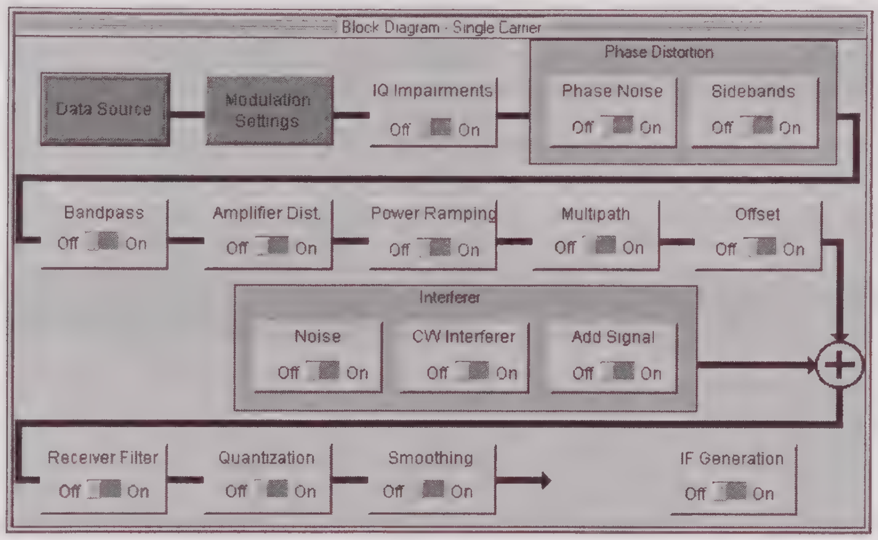


Fig. 3-3 Single-carrier block diagram

3.3.1 Display of Transmission Model and Signal Flow

Each section of the block diagram represents a functional component of signal generation. The block diagram therefore shows the transmission model used by WinIQSIM.

The first step in signal generation is the **Data Source.** Here the binary input data are defined. Only one data source is required for single-carrier transmission, several different data sources may be used for multicarrier and 3GPP W-CDMA transmissions.

The data source is followed by the **Modulation Settings** block. Here the modulation parameters of the single-carrier signal like type of modulation, coding, baseband filter, symbol rate and oversampling are set. In the case of multicarrier signals, the modulation settings block is replaced by the **Carrier Settings** block. In addition to other parameters, the number and position of the carriers, the modulation to be used and the carrier power are defined by this block. With the W-CDMA system selected, the **W-CDMA Configuration** block is displayed in the diagram instead. The active coding channels with channel power and interleaved coding can also be defined in this block. All other blocks are the same for all systems. They serve for simulating signal impairments and effects caused by the transmission channel and the receiver. These components will not be further described in this brief introduction.

The block diagram illustrates the signal flow in the program. For internal signal calculation, the signal passes through all the blocks in the diagram in the given order. When a new signal is to be defined, the components of the transmission model should be configured in the order given in the diagram beginning with the data source.

3.3.2 Control and Operation of WinIQSIM via the Block Diagram

The block diagram displays the transmission model and allows clear and simple operation of WinIQSIM. The diagram is not a passive display window but an active control tool.

A click with the left mouse key on any block in the diagram opens the respective setting window. The currently configured block is highlighted by an orange frame for ease of identification.

All blocks in the diagram except the data source and modulation settings blocks (or the corresponding blocks for multicarrier and 3GPP W-CDMA) can be switched on and off. Thus an individual impairment scenario can be created. The on/off function can also be controlled from the block diagram. To this end a switch is provided in the lower part of each block, which can be actuated by means of the left mouse key. A click on Off or On sets the switch to the respective position.

For a clear distinction of active and non-active blocks, the blocks are colour-coded. Active blocks (On) are displayed on a green background, non-active blocks (Off) on a grey one.

3.4 Example of Signal Configuration

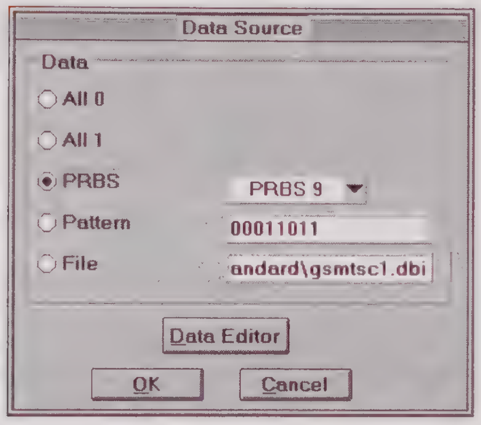
This section describes the configuration procedure for a single-carrier signal by way of an example. Signal impairments are not simulated. All impairment components are switched off (grey). The configuration of the block diagram is shown in Fig. 3-3 Single-carrier block diagram

.

The steps required for generating an I/Q signal from the selection of the data source and configuration of the modulation to the graphics display of the signal or the transmission to AMIQ are described in the sections below.

3.4.1 Selecting the Data Source

The binary data source to be used for I/Q signal generation is selected in the Data Source panel (first block in the diagram). Five different types of data sources are available. These are **All 0**, **All 1**, **PRBS**, **Pattern** and **File**. The desired data source can be selected by a mouse-click on the desired item (radio button).



Data Source

Data

○ All 0

○ All 1

● PRBS: PRBS 9

○ Pattern: 00011011

○ File: andard\gsmtsc1.dbi

Fig. 3-4 Data Source Panel

All 0: Data source All 0 sends a sequence of binary 0 symbols.

All 1: Data source All 1 sends a sequence of binary 1 symbols.

PRBS: This data source can generate different pseudo-random binary sequences. The types **PRBS 7**, **PRBS 9**, **PRBS 11**, **PRBS 15**, **PRBS 16**, **PRBS 20**, **PRBS 21** and **PRBS 23** can be selected in the field at the right of the PRBS button.

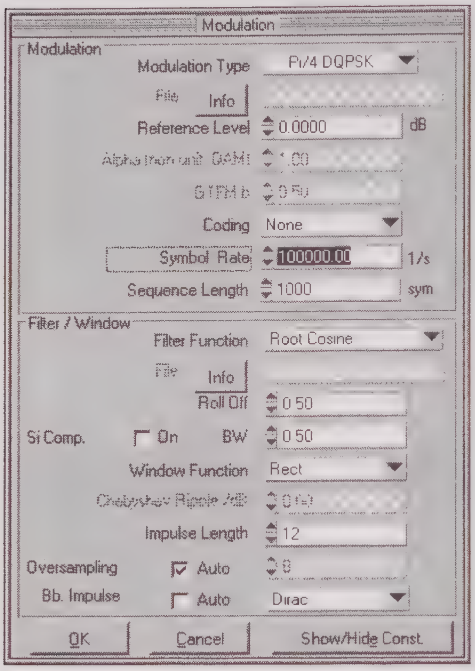
Pattern: A bit pattern can also be used as a data source. The currently set bit pattern is indicated at the right of the Pattern button. To change the pattern or to define a new one click on the bit pattern selection field with the left mouse key.

File: The data source may also be a data file. The selected file is indicated in the field at the right of the File selection box.

➢ The pseudo-random sequence **PRBS 9** is used as a signal source in Fig. 3-4.

3.4.2 Configuration of Modulation and Bandpass Filters

All modulation parameters of the signal are set in the Modulation Setting panel.



Modulation Type: Pi/4 DQPSK
Reference Level: 0.0000 dB
Alpha (for unit QAM): 1.00
GTFM b: 0.50
Coding: None
Symbol Rate: 100000.00 1/s
Sequence Length: 1000 sym
Filter Function: Root Cosine
Roll Off: 0.50
Si Comp. ☐ On BW: 0.50
Window Function: Rect
Chebyshev Ripple /dB: [illegible]
Impulse Length: 12
Oversampling ☑ Auto 8
Bb. Impulse ☐ Auto Dirac

Fig. 3-5 Modulation Setting panel used in the example

Type of modulation

This is the most important parameter of the panel. The selected type is indicated in the **Modulation Type** field. A click with the left mouse key on the field opens a two-level selection menu where the new type of modulation can be set.

The modulation types are organized in groups. The first group contains phase shift keying (**PSK**), the next quadrature amplitude modulation (**QAM**) and the last all the methods using frequency shift keying (**FSK**).

PSK modulation modes

WinIQSIM supports six types of PSK modulation: BPSK, QPSK, Offset QPSK, π/4 DQPSK, 8 PSK and 8 PSK EDGE.

QAM

Quadrature amplitude modulation is the second large modulation group. QAM uses phase and amplitude modulation. A modulation status or modulation symbol represents several input data bits. With 64QAM, for instance, a modulation symbol represents six input data bits. The transmission rate of these symbols is lower than the bit rate by a factor of six. WinIQSIM supports the following QAM modes: 16QAM, 32QAM, 64QAM and 256QAM.

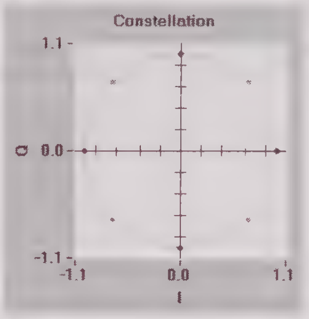
FSK

The third and last group are the digital frequency modulation modes (frequency shift keying). With FSK the frequency of the input symbols is shifted. WinIQSIM supports the following FSK modes: MSK, 2FSK, 4FSK and GTFM.

➢ In the example, π/4 **DQPSK** modulation is selected. π/4-shifted differentially encoded QPSK is a differential 4-phase modulation with an additional phase shift of π/4 at each modulation step.

Table 3-1 Assignment of data symbols to phase differences with π/4 DQPSK

Data symbol	Phase difference
00	45°
01	135°
10	225°
11	315°



The advantage of π/4 DQPSK is that phase transitions of +π or -π do not occur.

Modulationsparameter
Other parameters can also be configured depending on the selected modulation type. With the π/4 DQPSK modulation selected in the example, only the **reference level** is of interest.
Reference level: Here the maximum signal reference level used for PSK and QAM modulation is set.
➢ **0 dB** is set in the example.

Coding
The binary data stream from the source can be recorded with the aid of a coder. The coding types supported by WinIQSIM do not contain redundancies. The number of coder input bits corresponds to the number of output bits. Block coding is mainly used to adapt the mapping schemes supported by WinIQSIM to the requirements of the respective communications standards.

- Coding is not used in the example (**none**).

Symbol rate: The symbol rate must be set so that the correct clock rate of the I/Q source AMIQ can be set. Setting is performed in the **Symbol Rate** field.
The symbol rate can be varied between 10 symbols/s and 100 Msymbols/s.

- In the example a symbol rate of 100.000 symbols/s is set.

Sequence length: The sequence length specifies the length in data symbols of the I/Q signal to be calculated. A memory of max. 4 Msamples is available in the output RAM of AMIQ for each of the I and Q signals. In the single-carrier mode, the number of sampling values is the product of sequence length and oversampling.

- In the example a length of 1000 symbols is selected.

Baseband filtering and filter parameters
This section describes the selection of the baseband filter and of associated filter parameters. All baseband filters offered by WinIQSIM are lowpass filters.
The baseband filter and modulation play a decisive role in signal shaping in the frequency and time domain.
The output sequence of modulation mapping is a complex pulse sequence that is applied to the baseband filter. The filter output signal is obtained by a convolution of filter impulse response and complex modulation pulse sequence.
In WinIQSIM the following filter modes can be selected: None, Rect, Root Cosine, Cosine, Gaussian, Gaussian EDGE, PRS, user filter.

- In the example a **Root Cosine** filter with a **roll-off factor** of **0.6** is used.

Window function and window parameters
The impulse response of a filter to a data symbol is spread over several symbol periods. The number of symbol periods during which the impulse response of the filter is considered in the calculation of the I

and Q components is determined by the **Impulse Length**. The **Window Function** is an additional filter that can be placed over the impulse response for a period determined by the impulse length. The window function should be used with filters featuring a slowly decreasing impulse response (eg cosine filter) to reduce adjacent-channel interference.
In WinIQSIM five window functions can be selected: Rect, Hanning, Kaiser, Hamming, Chebyshev.

- A rectangular window is used in the example shown.

Impulse length
As already mentioned, the impulse length specifies the number of symbol periods of the filter impulse response that are considered in the I/Q calculation. The pulse length can be set between 1 and 32 symbol periods in the **Impulse Length** field.

- In the example an impulse length of 12 is used.

Oversampling
Oversampling determines the number of sampling values to be calculated for each symbol. This factor helps to increase the frequency offset of the aliasing products produced by D/A conversion of the signal. A good compromise for the oversampling factor are values between 4 and 12. Oversampling can be set between 1 and 32.
To simplify the selection of correct oversampling, the latter can also be automatically selected (check box **Auto**).

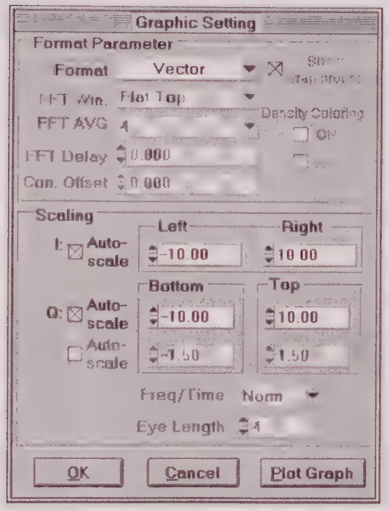
- In the example **Oversampling Auto** is selected.

Baseband pulse: In this field the baseband pulse used for exciting the baseband filter is selected.

- Auto is used in the example shown.

3.5 Graphics Representation of Configured Signal

The graphics panel is an important tool for viewing and checking the signal configuration. In this panel the generated I/Q signal or representations derived thereof like the vector diagram or the signal spectrum can be displayed.
The display format and associated graphics parameters can be selected and set in the Graphic Setting panel. The display scaling can also be selected.



Format: Vector ☒
FFT Win.: Flat Top
FFT AVG: 4
FFT Delay: 0.000
Can. Offset: 0.000
I: ☒ Auto-scale Left: -10.00 Right: 10.00
Q: ☒ Auto-scale Bottom: -10.00 Top: 10.00
☐ Auto-scale -1.50 1.50
Freq/Time: Norm
Eye Length: 4

Fig. 3-6 Graphic Setting panel used in the example

- ➢ Select the **Vector** format in the Graphic Setting panel and autoscaling for the I and Q axes. Press the Plot Graph button. The Graphics panel is displayed with the vector diagram as shown below. Then select for example the graphics format FFT MAG and press the Plot Graph button so that the FFT magnitude spectrum is displayed.

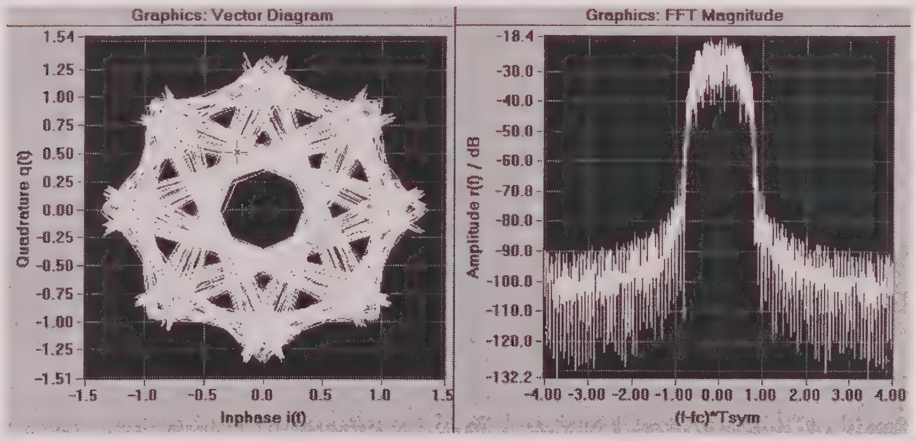
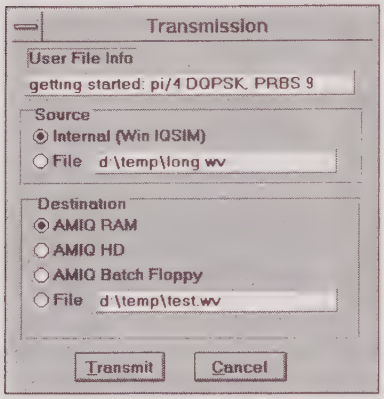


Fig. 3-7 Vector diagram and FFT magnitude spectrum of the defined signal

3.6 Transmitting the Signal to AMIQ

The defined signal can be transmitted to AMIQ in the Transmission panel (AMIQ: Transmission). Make sure that an AMIQ is really connected to your PC (GPIB/IEEE 488.2 or RS232).
Ensure that the **Internal 2.5 MHz filter** option is selected in the AMIQ Lowpass Filter panel. This prepares the I/Q signal for the internal 2.5 MHz lowpass filter of AMIQ (for details refer to chapter 5).
A comment on the current signal can be entered in the User File Info field. The comment is stored in the AMIQ together with the signal and can be read again.
Select **Internal (WinIQSIM)** as a signal source for transmitting the currently configured signal to AMIQ.
Select **AMIQ RAM** as the destination.



User File Info: getting started: pi/4 DQPSK, PRBS 9

Source
● Internal (Win IQSIM)
○ File d:\temp\long.wv

Destination
● AMIQ RAM
○ AMIQ HD
○ AMIQ Batch Floppy
○ File d:\temp\test.wv

Fig. 3-8 Transmission panel

- ➢ Start the selected **Internal => RAM** transmission with the Transmit button. A connection to AMIQ will be established and the signal file transmitted to the output RAM of AMIQ. If the **Automatically load and start...** option is selected in the Interface and Transmission Options panel, the signal in the AMIQ is output immediately after the transmission. The AMIQ output signal can be displayed for instance on an oscilloscope in the XY mode and compared to the vector diagram in the WinIQSIM graphics panel.

ROHDE&SCHWARZ

Test and Measurement
Division

Application Manual

Software WinIQSIM for Calculating I/Q Signals for Modulation Generator AMIQ

WinIQSIM

1027.3007.30

Printed in the Federal
Republic of Germany

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1 Introduction

1.1 How to use this manual

What you find here.

This booklet deals with applications (which is why it is called an *application manual.*) The main purpose is to give the WinIQSIM and AMIQ user some advice how to use the software to obtain optimum results. Concerning the topics, it focuses on the creation of multi-carrier signals. The applications reach from CW carriers to multi-carrier setups for TDMA systems, as well as W-CDMA and IS-95 scenarios. Another chapter explains how to get along with the AMIQ BER measurement function (option AMIQ-B1). Finally, a palette of more exotic applications is presented.

Besides practice you'll find some background explanations. This will sometimes require basic mathematics. But don't worry - theory doesn't play a major role in this work. What you won't find here are algorithms or other „inner secrets" of WinIQSIM. You may understand that we refuse to give away arcana.

What you find elsewhere.

To get really familiar with WinIQSIM and to make the best use of the AMIQ capabilities you should also read the user manuals of WinIQSIM and AMIQ. The WinIQSIM user manual describes all functions of the program and gives some background information of the available digital modulation and filtering, especially for W-CDMA signals.

This application manual doesn't cover hardware properties. To learn more about the AMIQ hardware, see the AMIQ user manual, where you'll also find a chapter about remote control via the GPIB or serial port.

What you should keep in mind.

This is not a tutorial for beginners. It's recommended that you have already worked a little bit with WinIQSIM and know how to create a waveform. If you're not familiar with the program at all, have a look at the WinIQSIM user manual first. Play around with the software, if you've got the 32bit version you can also use the online help.

Most of the chapters are independent of each other, so you don't need to read them in a special order. However it may be useful to read the W-CDMA part in the WinIQSIM user manual before dealing with multi carrier W-CDMA. On the other hand you should be familiar with the WinIQSIM data editor when working with the BER measurement features.

1.2 Conventions and definitions

The standard text font is Arial 12, *italic letters* denote emphasis on important terms. Expressions and parameters of WinIQSIM are typed in **bold** font. Menus and paths in WinIQSIM are indicated by `Courier` font.

References to equations are denoted by Eq., followed by the number of the equation. For example, „Eq. 2.5“ refers to equation number five in chapter 2.
In chapter 2 we will present some background information concerning properties of multi-carrier signals. Therefore we need the Fourier transformation for time t and frequency f as mathematical tool. We will use the following convention.

$$
\begin{aligned}
s(t) &= \frac{1}{2\pi}\int_{-\infty}^{\infty} S(\omega)e^{-i\omega t}\,d\omega \\
S(\omega) &= \int_{-\infty}^{\infty} s(t)e^{i\omega t}\,dt
\end{aligned}
\tag*{Eq. 1.1}
$$

with the angular frequency

$$\omega = 2\pi f$$

The symbol to denote the Fourier transformation is

$$s(t) \;\circ\!\!-\!\!\!-\!\!\!-\!\!\bullet\; S(\omega)$$

2 Basics of Signal Generation

2.1 Arbitrary waveform generators

Signal generators for today's communication market have to provide digitally modulated signals of near arbitrary complexity. To generate such complex signals, two different methods can be applied in principle. One is to generate the digital data in real-time, then modulate and convert it to analog - this is done for example with the SMIQ signal generator (options SMIQB10, B11).

The other way is to calculate a (finite) digitally modulated signal and store the values in a memory. The values are then read out sequentially and converted to analog (this is done again in real-time). The second solution is realized in *arbitrary waveform generators.*

The biggest advantage of an arbitrary waveform generator (ARB) comes from its flexibility. You can create any kind of waveform you like, just like drawing on a computer spreadsheet. The signal's value as a function of time is stored as a sequence of samples in the ARB's memory. This sequence is then played over and over again. So an ARB could also be named a sample player.

The realization of this conception is shown - in principle - in the block diagram of Fig. 2-1. A clock source delivers the time intervals for the samples following one another and controls the output of the waveform values. These are converted into analog voltages by the DAC.

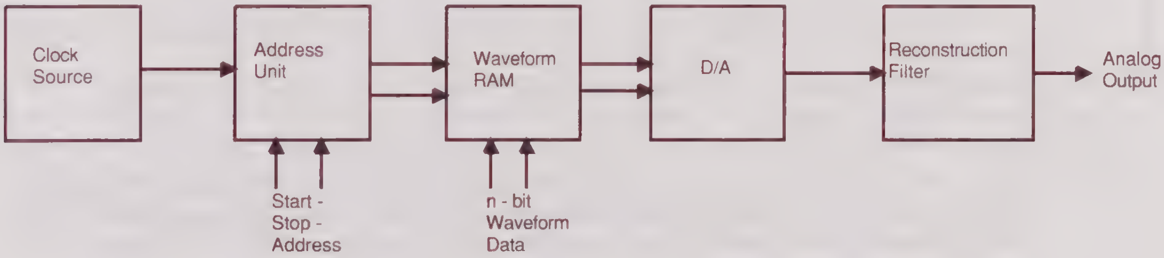


Fig. 2-1 Schematic block diagram of an ARB

2.2 Creating waveforms out of digital data

Although digital technology has provided lots of capabilities - and convenience - for signal generation, there are certain inherent properties of digitally created signals that have to be taken into account. To discuss this, we should remember some basic properties of time and frequency domains and the Fourier transformation coupling them. This will lead to a better understanding although we will not reach the level of a mathematical treatise. (A good introduction to the Fourier transformation and some of its applications is provided in W. Stößel's book „Fourieroptik" - see References).

So let's recall some rules before continuing with the topic:

- Time and frequency domains are reciprocal in several manners. Small quantities in time domain are related to big ones in frequency domain and vice versa.
- Signals with short duration in time (like pulses) have broad frequency spectra
- Signals with sharp edges in time domain (like rectangles) have broader frequency spectra than smooth signals. For example, a rectangular pulse has a spectrum of the shape sin(x)/x which

approaches zero slowly for increasing frequencies. A Gauss shaped pulse, on the other hand, has a Gauss shaped spectrum that approaches zero rather rapidly.

- With composite signals, fine structures in time domain are related to coarse structures in frequency domain and vice versa. Regard, for example, a time signal where a short pulse is repeated over and over again. This will lead to a frequency spectrum with spectral lines determined by the period of the pulse repetition. The Fourier transform of the pulse itself will play the role of the envelope of the spectrum [1].
- Periodically repeated sharp events (like jumps, edges) in the time domain will lead to equidistant spectral lines in the frequency domain [2].

As shown in Fig. 2-2 an assumed ideal signal is approximated by a sequence of discrete rectangular pulses. Representing a signal with discrete samples at defined time intervals generally leads to some unwanted spectral properties. Besides a certain quantization noise - which can be decreased by using high resolution D/A converters - one has to deal with two effects due to the discrete nature of the signal. First, the use of rectangular pulses results in a very broad spectrum. On the other hand the discrete time intervals lead to a repetition of the signal round the clock frequency, the so-called aliasing products. These two effects can be eliminated by certain filtering techniques.

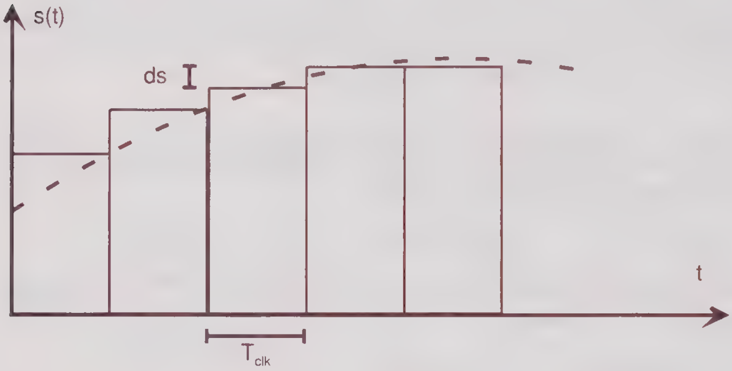


Fig. 2-2: An ideal time signal (broken line) and its realization with digital technology. The signal is approximated very closely by a sequence of rectangular pulses with equal width T_{clk} and varying heights (ds is the amplitude resolution). The inverse $f_{clk}=1/T_{clk}$ of the pulse width is called sample or clock rate.

(a) Limiting the spectrum - digital baseband filtering

A rectangular pulse has an unlimited bandwidth in frequency domain. If the pulse is decribed as

$$s(t)=\begin{cases}1 & -\tau\le t<\tau\\ 0 & \text{elsewhere}\end{cases}$$

in time domain, the Fourier transform is

$$S(\omega)=2\tau\frac{\sin(\omega\tau)}{\omega\tau}\quad \text{with}\quad \omega=2\pi f$$

---

[1] The mathematics behind this is the following. The composite time signal can be described with the convolution of the pulse signal with a so-called Dirac comb which describes the periodic repetition. The Fourier transform of a Dirac comb is again a Dirac comb, these are the spectral lines. The convolution turns to a multiplication in frequency domain. So one obtains a product of the frequency Dirac comb and the Fourier transform of the pulse. According to the reciprocity, the spectrum of the pulse is much broader than the spectral lines and therefore becomes the envelope of the entire spectrum. For details see mathematical literature or the book by W. Stößel (see References).

[2] This is again based on the fact that the Fourier transform of a Dirac comb is also a Dirac comb.

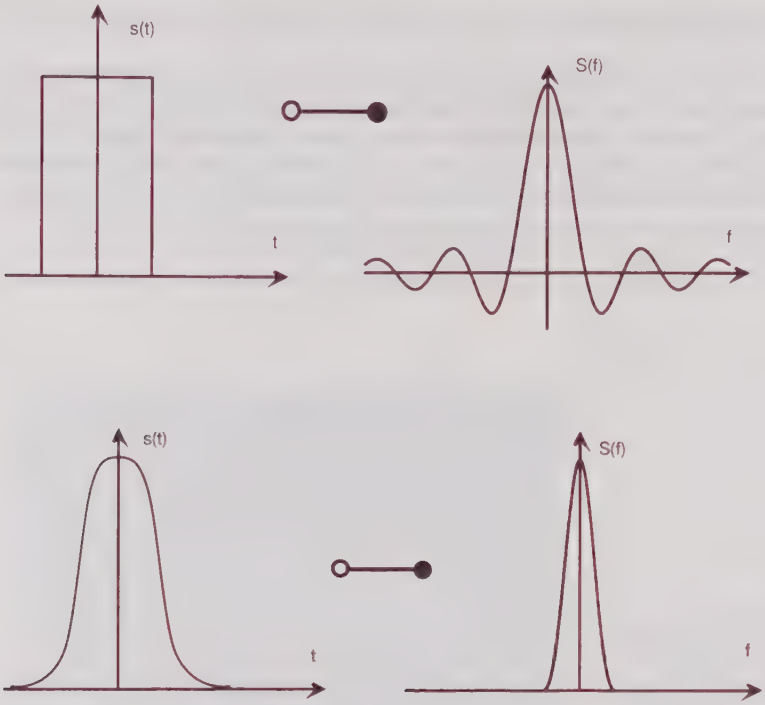


Fig. 2-3: Smoothing a rectangular pulse with a filter limits the spectral bandwidth.

This (amplitude) spectrum is shown in Fig. 2-3 (upper right). The hard steps at the edge of the pulse lead to the ripples on both sides of the spectrum. Smoothing of the steps by filtering suppresses these ripples, leading to a limited bandwidth (lower right). Mathematically this is done by convoluting the pulse function with the filter response function in time domain.

(b) Suppressing repetitions - antialiasing filtering

The discrete nature of the digital signal as a function of time, represented by rectangular pulses following each other, leads to a sequence of hard steps in time. In every time interval T_{clk} the value of the signal changes instantaneously [3]. This ends up in repeated spectra of the modulation at frequencies $n \cdot 1/T_{clk}$, which are called aliasing products. These are neither wanted nor needed, for all relevant information is contained in the „original“ modulation spectrum around f=0 and one cannot transmit with unlimited bandwidth. Therefore aliasing products are usually suppressed by (analog) low pass filters.

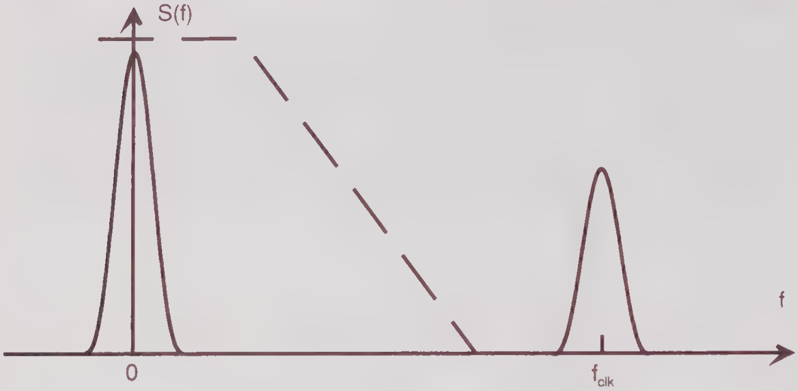


Fig. 2-4: A hardware low pass filter with appropriate cutoff suppresses aliasing products.

---

[3] This is the Dirac comb argument once more, just a little generalized.

(c) Avoiding clock spurs - the continuous wraparound

The ARB conception of playing a waveform of finite length over and over again forces another necessary property of the signal: the beginning and end of a sequence have to match. Otherwise a step in the signal would be generated every time the waveform starts again - this would in turn again lead to disturbances in the frequency spectrum [4]. So the waveform has to be designed in a manner that it is continuous, including the transition from one end to the next starting (called wraparound) [5].

To fulfill this condition one can either use more or less intelligent smoothing algorithms or design signals that match the condition by themselves. WinIQSIM provides tools for both methods.

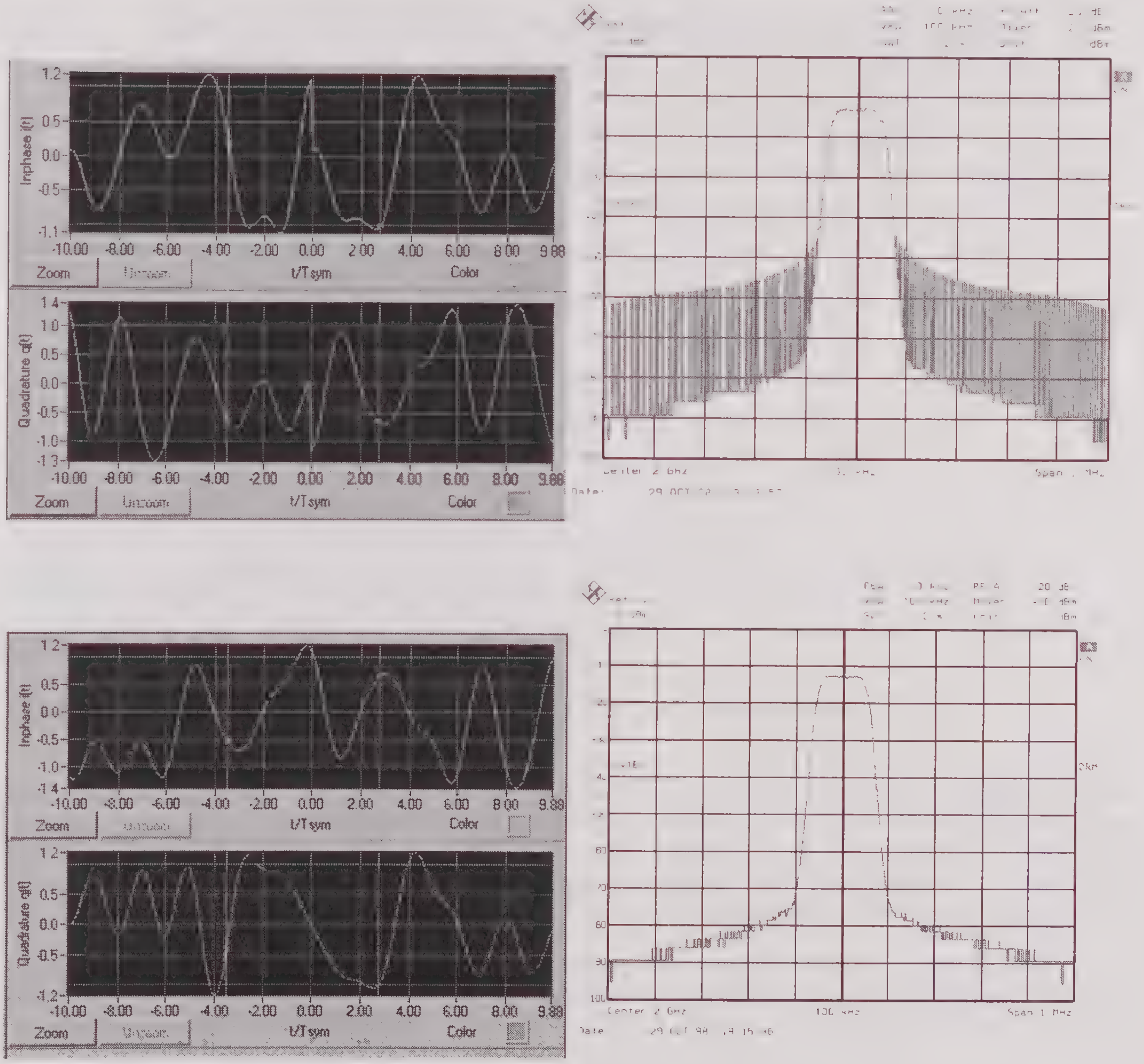


Fig. 2-5: *If the beginning and the end of a waveform sequence don't match, a jump occurs at the wraparound. This leads to significant spurs in the frequency spectrum (upper figures). On the other hand, a smooth signal gives a clean spectrum (lower figures).*

---

[4] As you see, the Dirac comb is a permanent guest in our discussion. The main difference to the case (b) is that the period of the steps in time domain is much larger now. This gives in turn a small period in frequency domain, the teeth of the comb are close to each other in the spectrum.

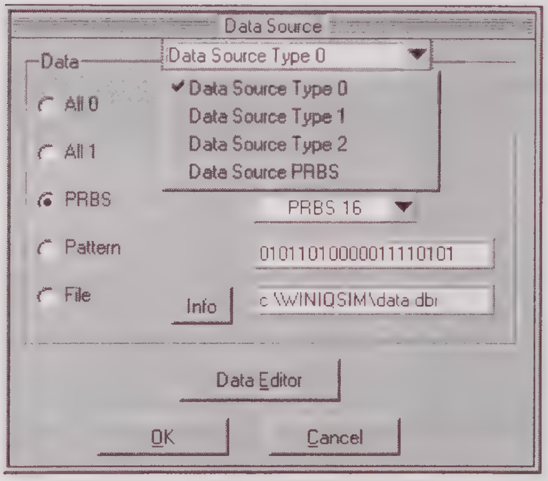
[5] In fact, the condition is even stronger: the waveform has to be continuous (= without steps) and differentiable (= smooth).

3 Signal Generation with WinIQSIM

Before we start with the application lectures, we will run shortly through the most important panels of WinIQSIM. This is not an introduction for beginners or something like a tutorial. The aim is more to give some advice on the different menus which is not so easily found in the user manual. Furthermore one may focus on several points that can be clarified better from an integrative point of view. For a complete description of all functions we refer to the WinIQSIM user manual.

3.1 Before calculation: from data source to graphic settings

Data source



Data

○ All 0

○ All 1

● PRBS PRBS 16

○ Pattern 01011010000011110101

○ File c:\WINIQSIM\data.dbi

Fig. 3-1: Data source panel in Multi Carrier, W-CDMA and IS-95 systems.

The Multi Carrier, W-CDMA and IS-95 systems provide four different data sources. Sources 0 to 2 have the same features as the data source in single carrier. The source named **PRBS** has some special features. One is the function „**different start values for PRBS**“ in the system settings. This function feeds each carrier (or code channel) using data source PRBS with a different start value for the polynomial generation of the PN sequence. This leads to uncorrelated data in the different channels. [6]

To set the data sources, one must choose the appropriate source from the pop-up table at the top of the panel. Then one adjusts the parameters for this source. For example, in Fig. 3-1 **Data Source Type 0** is chosen and set to data type **PRBS 16**,

WinIQSIM systems and settings

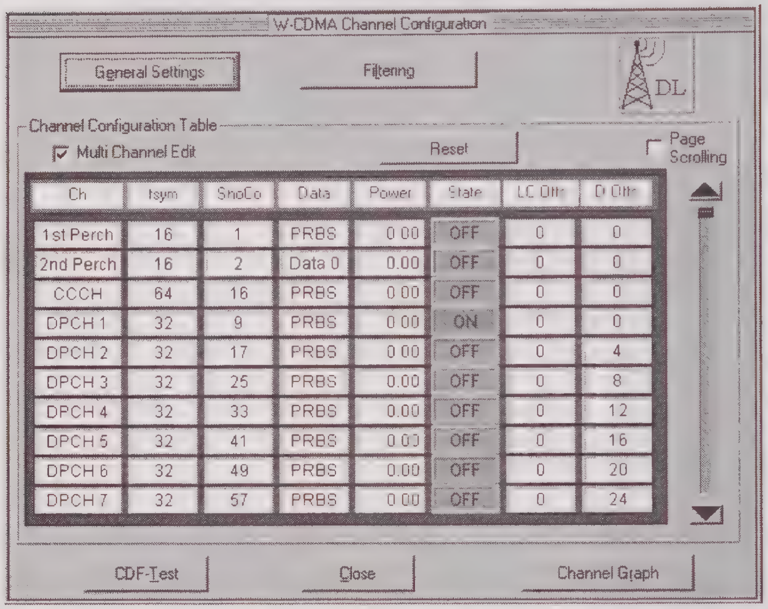
WinIQSIM provides five different complete systems of digital modulation: `Single Carrier`, `Multi Carrier`, `Multi Carrier Mixed Signal`, `W-CDMA` and `IS-95`. In the `Single Carrier` system the `modulation settings` follow the `data source` in the block diagram. With `W-CDMA` and `IS-95` the `modulation settings` are integrated as a submenu in the system settings. The latter are called

---

[6] The other data sources can also be set to generate PRBS sequences, but don't have the „different start values“ option.

`W-CDMA configuration` or `IS-95 configuration`, respectively. In `W-CDMA` the modulation parameters are partly fixed according to the standard, so only the filter parameters are accessible.
In `Multi Carrier` the system settings (here called `Carrier Settings`) are placed right at the end of the block diagram. The reason for this is that `Multi Carrier` allows combinations of modulated and unmodulated carriers. *All parts of the block diagram before the carrier settings - including modulation and all kind of impairments - affect only the modulated carriers, not the unmodulated.*

The system settings are the principal menues, defining the signal setup in such essential parameters as number and relative power of carriers or code channels, respectively. In these menues one also links the carriers (or channels) to the possible signal sources.



Ch	tsym	SnoCo	Data	Power	State	LC Off	D Off
1st Perch	16	1	PRBS	0.00	OFF	0	0
2nd Perch	16	2	Data 0	0.00	OFF	0	0
CCCH	64	16	PRBS	0.00	OFF	0	0
DPCH 1	32	9	PRBS	0.00	ON	0	0
DPCH 2	32	17	PRBS	0.00	OFF	0	4
DPCH 3	32	25	PRBS	0.00	OFF	0	8
DPCH 4	32	33	PRBS	0.00	OFF	0	12
DPCH 5	32	41	PRBS	0.00	OFF	0	16
DPCH 6	32	49	PRBS	0.00	OFF	0	20
DPCH 7	32	57	PRBS	0.00	OFF	0	24

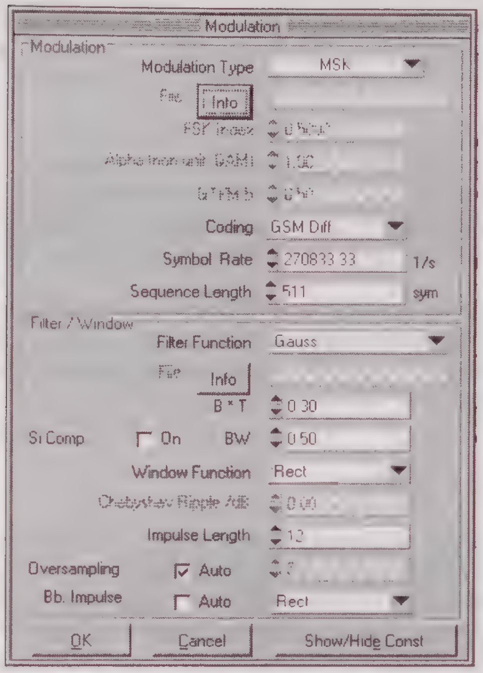
Fig. 3-2: An example for system settings: the W-CDMA configuration panel in the W-CDMA system.

Modulation settings

The modulation settings are described in depth in the WinIQSIM user manual. We only want to state some additional hints at this point.

The purpose of the **modulation type CW** is to create an *unmodulated RF carrier*. With an I/Q modulator this is done by a DC voltage on the I and Q outputs (usually +0.5 V on I and zero voltage on Q, with variations depending on the required phase of the carrier). Therefore **CW** delivers a constant baseband signal rather than a sinewave. As WinIQSIM is not designed for function generation, there is no sinewave function implemented. Despite this one may create a baseband sinewave signal using the **frequency offset** function (see chapter 6).

To generate signals of textbook character, i.e. digital signals without any baseband filtering, a careful use of filter parameters is recommended. The modulation types **PSK** and **QAM** use Dirac pulses as baseband impulses. To obtain a sequence of rectangular pulses one has to use the filter type **rect**, not **none**, with Dirac baseband impulses. Filter type **none** leaves the baseband impulses unchanged and has to be used only with modulations where the baseband impulses have rectangular shape (e.g. **FSK** in default settings).



Modulation Type: MSK
Coding: GSM Diff
Symbol Rate: 270833.33 1/s
Sequence Length: 511 sym
Filter Function: Gauss
B * T: 0.30
Si Comp ☐ On BW: 0.50
Window Function: Rect
Impulse Length: 12
Oversampling ☑ Auto
Bb. Impulse ☐ Auto Rect

Fig. 3-3: Modulation settings panel in the single carrier system (shown as an example).

Offset and add signal functions in Multi Carrier system

One special issue of the `offset` function in the `Multi Carrier` system should be mentioned here. In the `Single Carrier`, `IS-95` and `W-CDMA` systems the **frequency offset** values refer to symbol rate times oversampling which is equal to the overall sample rate in these cases. In `Multi Carrier` system, although the values also refer to symbol rate times oversampling this is not the overall sampling rate which is defined by (see the WinIQSIM user manual)

$$f_{sample} = m_{SOV} \cdot \left[(N_{car} - 1) \cdot \Delta f_{car} + l_{OV} \cdot f_{sym} \right]$$

with the sampling rate f_{sample}, the super oversampling factor m_{SOV}, the number of carriers N_{car}, the carrier spacing Df_{car}, the oversampling factor l_{OV} and the symbol rate f_{sym}.

The `offset` and `add signal` functions affect all modulated carriers in the same way - as everything else in the block diagram before the `Carrier Settings`. In practice, they can be used to shift those carriers a little to the left or right and, respectively, to add e.g. an interferer to each modulated carrier. It is not possible to realize complex „multiple multi carrier setups“ in this way.

3.2 After calculation: antialiasing, resampling and waveform transmission

The waveform calculated in WinIQSIM must be transmitted to AMIQ to be realized. This can be done in a number of ways and with several options. Therefore some additional explanations might be useful.

WinIQSIM can prepare the waveform data for use in AMIQ in several ways. In any case, the signal is recalculated for sin(x)/x compensation to get best performance out of the hardware for the digital communication systems. This may result in some overshooting with textbook-like unfiltered rectangular sequences [7]. On the other hand, precise rectangular sequences can easily be realized by writing a sequence of appropriate I and Q values in an ASCII file and converting these with AMIQ-K2 software.

The resampling process

Sometimes a waveform has to be recalculated to meet the AMIQ hardware requirements. This is done in two different cases.

First, the AMIQ needs a total number of samples that is a multiple of four if the AMIQ works in clock rate mode 2 (fast mode, for clock rates > 4 MHz). WinIQSIM recalculates the waveform to fulfill this condition. The physical parameters of the waveform itself (symbol rate, sequence length, and so on) naturally remain unchanged. This process is called resampling.

The automatic resampling function (AMIQ --> low pass filter... menu)

Resampling may also be needed to use the AMIQ low pass filters. For example, think of a waveform with a symbol rate of 1 MHz and oversampling 5. The sample rate is then 5 MHz. Although, if one wants to use the 2.5 MHz low pass filter to suppress aliasing products, the sample rate has to be at least 7.5 MHz plus half of the bandwidth of the signal. The automatic resampling function can be used to modify the sample rate automatically without touching the physical parameters of the signal (see Fig. 3-4). This function can be found in the menu `AMIQ --> Lowpass filter...` Preparation for the **2.5 MHz** or the **25 MHz** AMIQ internal filters can be selected. It is also possible to prepare for **external filters** if one knows the parameters of the filter shape. Choosing **no filter** turns off the resampling function.

To wipe out some misunderstanding: the menu `AMIQ --> Lowpass filter...` has nothing to do with turning on or off the AMIQ filters themselves! Control of the AMIQ filtering is done in the menu `AMIQ --> Remote Control and BERT --> Hardware Settings`. Of course it is possible to use the filters without the automatic resampling. (If one designs the signal with the right clock rate from the beginning, one doesn't need the automatic resampling.)

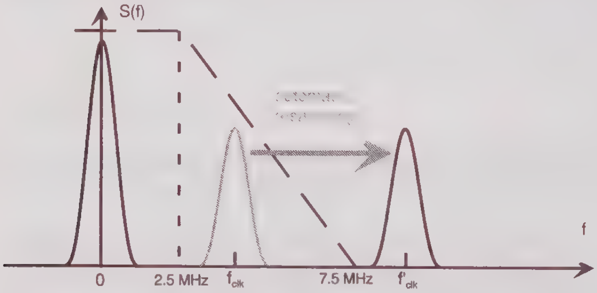


Fig. 3-4: The automatic resampling function of WinIQSIM prepares a waveform for use of antialiasing low pass filters before transmission to AMIQ (here shown for the AMIQ internal 2.5 MHz filter). If the sampling rate of the waveform is too small, leading to aliasing products inside the filter range, the signal is resampled. The sampling rate is increased by introducing a higher oversampling factor while the physical parameters of the signal remain unchanged. Then the aliasing products are shifted towards higher frequencies into the stopband range and can be suppressed by the antialiasing filter.

---

[7] One should not mix up this internal compensation for optimizing AMIQ performance with the function sin(x)/x compensation in the Modulation Settings panel of WinIQSIM. With the latter, the user may introduce additional sin(x)/x compensation for special purposes.

4 Multi Carrier Signals

WinIQSIM offers two features for creating *multi-carrier signals*, i.e. setups consisting of several (modulated or unmodulated) signals spreaded over different frequencies around an RF carrier. With the `Multi Carrier` system the user can combine modulated carriers of one single modulation type (and additional unmodulated carriers). This system is especially designed for scenarios with TDMA systems, e.g. many NADC carriers with definite frequency separation.

With the `Multi Carrier mixed` system signals consisting of several CDMA or WCDMA carriers or carriers of different modulation types can be built. First one creates the several single carriers and then one mixes them together. Both methods of generation are described in this chapter. A basic explanation of the properties and the special problems of multi carrier signals is presented, followed by practical applications.

4.1 Multi carrier scenarios in frequency and time domain

First, this chapter must derive some general properties of multi carrier signals and discuss their relevance to signal generation in an arbitrary waveform generator. This will require at least a small portion of mathematics. However, as in chapter 2 we will restrict ourselves and only outline the basic arguments.

What do we call a multi carrier scenario? A typical one is sketched in Fig. 4-1. In this chapter calculations will be done in the baseband regime, so the axis of ordinates denotes the position of the RF carrier.

Consider an arbitrary modulated baseband signal s(t) with a frequency spectrum S(f). We assume baseband filtering so that s(t) is continuous and S(f) has a limited width of approximately the symbol rate f_{sym}. The spectrum S(f) gives the shape of the carrier due to the modulation and will be referred to as *modulation spectrum.*

We start by regarding a very simple scenario with two (identical) modulated carriers, placed symmetrically at +/- f_{off} around the y-axis. The frequency spacing 2 f_{off} between the carriers shall be much bigger than the symbol rate f_{sym} of the modulation [8]. Such a scenario can easily be composed by copying S(f) onto the required positions on the f-axis. This is done by convoluting S(f) with Dirac delta functions $\delta(f+f_{off})$ and $\delta(f-f_{off})$. The entire signal in frequency domain is then

$$Z(f) = S(f)*\left[\delta(f-f_{off})+\delta(f+f_{off})\right] \qquad \text{Eq. 4.1}$$

Fourier transformation leads to the signal in time domain. The convolution integral gives a product after transforming, so

$$z(t) = s(t)\cdot 2\cos(2\pi f_{off}\,t) \qquad \text{Eq. 4.2}$$

---

[8] We could also skip this condition without damage - and will do so later - but $f_{off} >> f_{sym}$ gives scenarios which can be conveniently drawn in graphic plots.

The Fourier transform of the two Dirac functions is just a cosine with angular frequency $2\pi f_{off}$. The signal in time domain z(t) is a product of the modulation s(t) and a factor $\cos(2\pi f_{off} t)$ resulting from the carrier offsets $\pm f_{off}$ which we therefore call *offset oscillation.*

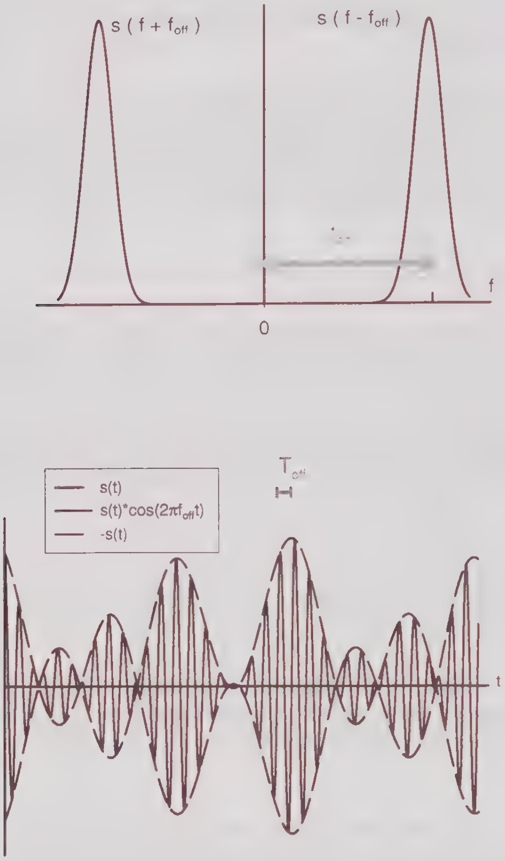


Fig. 4-1: A multi carrier scenario in frequency domain (upper drawing) with two identical carriers, placed symmetrically to the RF frequency (=origin) and the corresponding time signal $s(t)\cdot \cos(2\pi f_{off} t)$ (lower drawing). The spectrum $S(f \pm f_{off})$ of the modulation is related to the envelope $\pm s(t)$ of the time signal. The carrier positions, determined by $\pm f_{off}$, corresponds to the period $T_{off}=1/f_{off}$ of the fast oscillation.

A qualitative graphic representation of this scenario in frequency and time domain is shown in Fig. 4-1 (upper drawing - frequency domain, lower drawing - time domain). This is a good example for demonstrating that time and frequency domains are reciprocal. In our frequency spectrum the bandwidth of the carriers is small compared to the carrier spacing. So the carrier shape may be called the fine structure of the spectrum. On the other hand the carrier configuration (determined by the parameter f_{off}) is the coarse structure of the scenario. According to the rules mentioned in chapter 2, the configuration is related to the fine structure of the signal in time domain, represented by the fast oscillation with period $T_{off}=1/f_{off}$ - while the carrier shape is related to the rather slow variation in time of the modulation, becoming the envelope of the entire time signal.

It is now a straightforward procedure to generalize this to a setup of n (different) carriers with offsets $f_{off}^{(n)}$ (which can also be negative now). In the frequency domain we get

$$Z(f)=\sum_{i=1}^{n} S_i(f)*\delta(f-f_{off}^{(i)}) \qquad \text{Eq. 4.3}$$

Every multi carrier signal in frequency domain can be described by a sum of carriers, each being a product of the modulation spectrum and a Dirac function representing a spectral line. The former determines the *shape* of the carrier, the latter its *position.*

Fourier transformation leads to the time-dependent signal

$$z(t)=\sum_{i=1}^{n} s_i(t)\cdot\exp\left\{2i\pi f_{off}^{(i)}t\right\} \qquad \text{Eq. 4.4}$$

Every multi carrier signal in time domain can be described by a superposition of time signals, each consisting of an envelope factor $s_i(t)$ due to the modulation and an oscillation term [9].

Now it's time to investigate the consequences of these properties for the realization in arbitrary waveform generators.

4.2 The double wraparound problem

Arbitrary waveform generators always use signals of finite length stored in some kind of memory. Continous output is obtained by repeating the same sequence over and over again. As described in chapter two, for generating real continuous analog signals, the beginning and end of a stored sequence must match. Mathematically spoken, we need periodic boundary conditions.

Suppose we have stored a waveform sequence z(t) with length (duration) T_{seq}. Then

$$z(0)\overset{!}{=}z(T_{seq}) \qquad \text{Eq. 4.5}$$

In general, there is no chance to obtain a single set of rules to fulfill this condition for all modulation types and carrier setups. Additionally it would be rather hard finding necessary conditions for boundary periodicity. We will subdivide the problem instead by introducing conditions both for modulation and carrier offsets to ensure periodicity.

If we want to fulfill Eq. 4.5 for any arbitrary set of carrier offsets and modulations this leads necessarily to periodic boundary conditions for each modulation and offset

$$\begin{aligned} s_i(0) &\overset{!}{=} s_i(T_{seq}) \\ 1 &\overset{!}{=} \exp\left\{2i\pi f_{off}^{(i)}T_{seq}\right\} \end{aligned} \qquad i=1\ldots n \qquad \text{Eq. 4.6a and b}$$

---

[9] If f_{off} is in the same range as f_{sym} so the carriers overlap, it is hard to tell the two factors from each other, there is no longer a significant envelope. But the mathematical description stays the same.

The latter equation gives

$$f_{off}^{(i)}T_{seq} = m, \quad m \in \mathrm{Z} \qquad \textit{Eq. 4.7}$$

or

$$f_{off}^{(i)} = m \cdot f_{seq}, \quad m \in \mathrm{Z}, \quad f_{seq} = 1/T_{seq} \qquad \textit{Eq. 4.8}$$

As a result of the above relationship, each carrier offset $f_{off}^{(i)}$ must be an integer multiple of the repetition rate f_{seq} of the sequence. One could also call f_{seq} the *frequency resolution* of suitable carrier spacings.

The duration of the sequence T_{seq} is given by

$$T_{seq} = n_{sym} / f_{sym} \qquad \textit{Eq. 4.9}$$

with the symbol period $1/f_{sym}$ and the number of symbols (called sequence length) n_{sym}. Therefore

$$f_{seq} = f_{sym} / n_{sym} \qquad \textit{Eq. 4.10}$$

and

$$f_{off}^{(i)} = m \cdot f_{sym} / n_{sym} \qquad \textit{Eq. 4.11}$$

Now we have derived an essential and easy to apply condition for the design of multi carrier signals with an ARB:

The frequency offset of each carrier has to be an integer multiple of the repetition rate of the stored sequence, where the repetition rate is given by the symbol rate divided by the number of symbols.

In principle, there is another way to get rid of wraparound jumps - think of an algorithm that smoothes the waveform at the transition. This method is also provided by WinIQSIM (`smoothing` panel) and is useful for wraparound problems due to the modulation type with single carrier signals. It is not suitable for most multi carrier applications, especially with rather large carrier offsets. In this case the variation of the signal in time is mostly determined by the offset oscillations. If Eq. 4.11 does not hold, the periodicity of the oscillations is disturbed at the wraparound. A smoothing algorithm can remove steps at the wraparound, but the periodicity of the oscillations will still be disturbed. That means, even a smoothed wraparound is a single event in the signal. This event is repeated periodically and leads again to unwanted contributions to the frequency spectrum, decreased, but not suppressed by the smoothing algorithm.

Let's turn to practice for a moment. Multi carrier setups in WinIQSIM are controlled by four general parameters: the number of carriers, their relative power, phase and the (general) carrier spacing. So at the first look the program allows only equally-spaced carriers. Despite this one may achieve settings with different spacings by turning off some carriers.

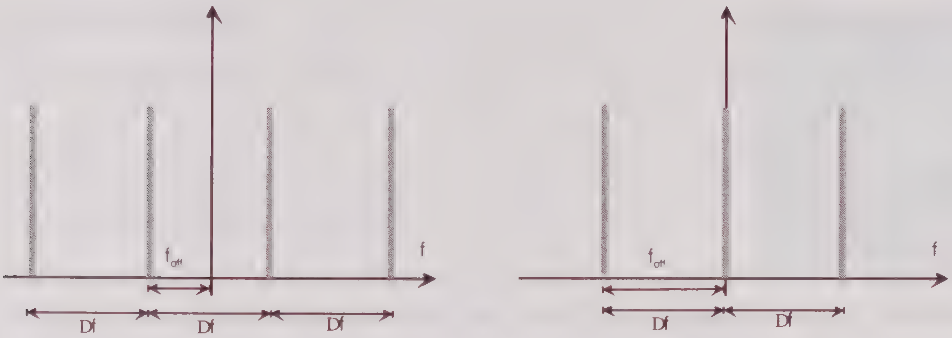


Fig. 4-2: *The two different basic multi carrier setups in WinIQSIM. Even numbers of carriers are distributed symmetrically to the RF frequency (left). Then the carrier spacing is just twice the offset of the two inner carriers. With odd numbers of carriers the central one is placed on the RF frequency and the carrier spacing is equal to the offset of the two neighbouring carriers (right).*

In general one has to distinguish between two cases. For settings with even numbers of carriers the carrier spacing Δf is just twice the offset of the two inner carriers (see Fig. 4-2) [10]. Therefore

$$\Delta f = 2m \cdot f_{sym} / n_{sym}, \quad \text{even number of carriers} \qquad \text{Eq. 4.12}$$

With odd numbers of carriers the central carrier is placed at the RF frequency and Δf is equal to the frequency offset of the carriers next to the center.

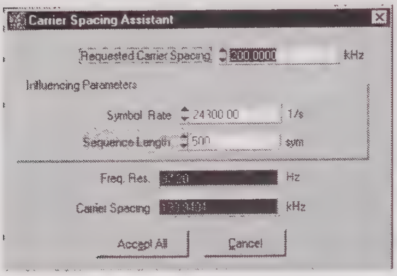
$$\Delta f = m \cdot f_{sym} / n_{sym}, \quad \text{odd number of carriers} \qquad \text{Eq. 4.13}$$

To make life easier for the user, WinIQSIM offers a so-called **assistant** function for the carrier settings. This function asks for the desired carrier spacing and calculates a value for Δf nearest to the desired one according to the rules outlined above. As one may want to turn carriers on and off in some settings without changing anything else, the assistant doesn't distinguish between even and odd numbers of carriers. To avoid confusion, always Eq. 4.12 is taken into account.

The relevance of Eqs. 4-11 and 4-12 can be demonstrated effectively with WinIQSIM itself. Imagine a signal with two carriers, each modulated with f_{sym}=24.3 kHz. The desired carrier spacing shall be 200 kHz, the sequence length 500 symbols. The assistant function of WinIQSIM calculates the correct spacing according to Eq. 4-12 (see Fig. 4-3). Fig. 4-4 shows two calculated waveforms with the above parameters. The upper waveform was calculated with the values suggested by the assistant function and has a corrrect wraparound. In the second case the assistant was ignored, which results in a wraparound jump and therefore in a faulty signal.

---

[10] As one can see from Fig. 4-2, the offsets of the outer carriers are all multiples of f_{off}. So if Eq. 4.11 holds for the two inner carriers, it is also fulfilled for all others. The situation is similar for odd numbers of carriers except for the missing factor 2 in Eq. 4.13.



Carrier Spacing Assistant

Requested Carrier Spacing 200.0000 kHz

Influencing Parameters

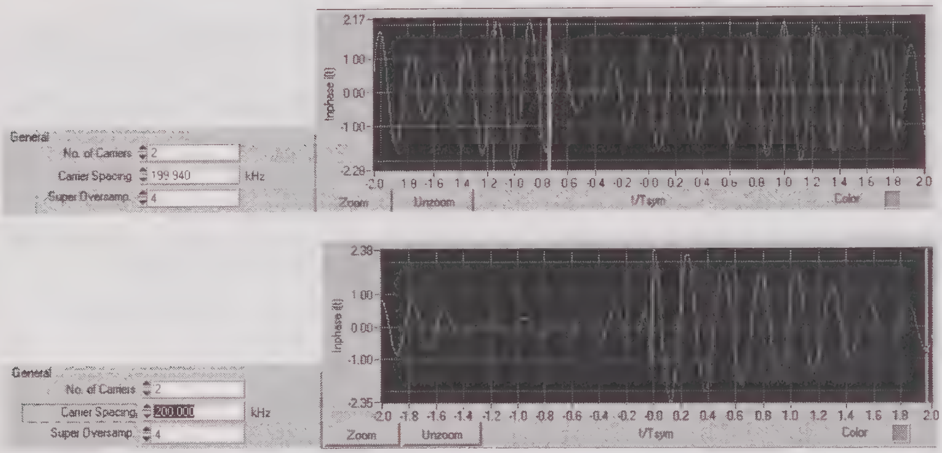
Symbol Rate 24300.00 1/s

Sequence Length 500 sym

Freq. Res. 97.20 Hz

Carrier Spacing 199.9404 kHz

Fig. 4-3: *Parameters suggested by the carrier spacing assistant for the example outlined in the text.*



General

No. of Carriers 2

Carrier Spacing 199.940 kHz

Super Oversamp. 4

General

No. of Carriers 2

Carrier Spacing 200.000 kHz

Super Oversamp. 4

Fig. 4-4: *If the carrier spacing is chosen according to Eq. 4.12 as suggested by the assistant, the wraparound is correct (upper figures). Carrier spacings where Eq. 4.12 does not hold result in faulty signals (lower figures).*

Now we have obtained an easy-to-use condition for the carrier offsets. It remains to solve the boundary (or so-called wraparound) problem for the modulation.

4.3 Solutions for different modulation types

One could go on like in the last section and try to solve the wraparound problem analytically for each type of modulation. Such a procedure is beyond the scope of this manual. It makes more sense to write down some empirical conditions for the most important modulations.

(a) BPSK, QPSK, O-QPSK and 8PSK without PSK rotation

Applications are for example CDMA and some satellite systems.

These modulation types are not greatly concerned with the wraparound. The only matter to be taken into account are the values of some internal parameters in WinIQSIM for calculating the filter response. These suggest using a sequence length of at least 130 symbols. Keeping this in mind, one shouldn't get any wraparound discontinuities with PSK modulations.

As the signal path is a linear system there is no problem with multiple access systems like CDMA. If the signal of each channel is continuous, so is the sum of all channels.

(b) QAM modulations

QAM modulations can be treated in the same way as PSK modulations - see case (a).

(c) MSK

The best known application is GSM.

MSK signals have a continuous wraparound if the sequence length is chosen to be a multiple of four.

(d) $\pi/4$ DQPSK (for NADC, PDC, PHS, TETRA and more)

All differential modulation types are difficult to handle because the signals have a „memory“. That is, a certain state (signal in a certain time interval (t, t+dt)) depends of the states that occured before t. Therefore a differential modulated sequence should be calculated, in principle, self-consistently with keeping the periodic boundary condition Eq. 4.5. This is rather arduous for MC scenarios. What can be done instead is forcing the system to get back to its initial state at the end of the sequence period. For $\pi/4$ DQPSK this works as follows.

(i) Use the WinIQSIM `data editor` to create a **data field** of N symbols (= 2N data bits) with any data you like (maybe PRBS). This sequence starts at a certain IQ state and ends at another one. Generally the initial and final states will be different [11]. See also Fig. 4-5 for the arguments. Now the angular difference between initial and final state is always a multiple of $\pi/4$ (45° or 90° or...), no matter what kind of data is used.

(ii) Build a **slot** by repeating this **data field** eight times. This sequence as data source ensures that the resulting angular difference between initial and final state is always a multiple of $8^* \pi/4 = 2\pi$. The system always returns to the initial state at the end of the sequence (see Fig. 4-5). This leads to smooth behaviour at the wraparound.

It is also possible to manage without the `data editor`. Choose for example **PRBS 9** as **data source**. This is a sequence of 511 bits. As we have a modulation of order 2 we need 8*2*511 bits = 8*511 symbols = 4088 symbols to return certainly to the initial state [12].

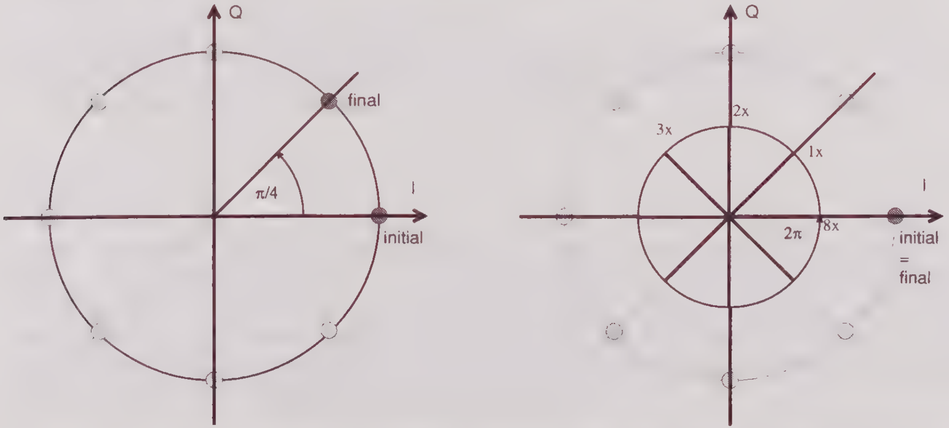


Fig. 4-5: Angular difference between the initial and final states of a $\pi/4$ DQPSK modulated sequence is always a multiple of $\pi/4$ (left). Repeating the same sequence eight times leads to an angular difference of $n \cdot 2\pi$ (right).

---

[11] The final state may be the same as the initial one, but this is the only case without any wraparound problem.

[12] The reason for the factor 2 is the following. A PRBS9 sequence is 511 bits long. As 511 is an odd number, you cannot build a complete sequence of QPSK symbols with it. (This would give 255 and 1/2 symbols.) For a symbol sequence with a complete, unbroken PRBS9 we need therefore the 511 bits twice . Repeating this sequence eight times gives 8 * 511 = 4088 Symbols.

(e) PSK modulations with additional PSK rotation

Coming application will be EDGE.

If an additional PSK rotation is applied to the mapping, the situation is in some ways similar to the differential modulation. PSK rotation allows the mapping constellation for each symbol interval to be rotated (in the mathematically positive direction) by the selected phase. The rotation parameter can be set as $r \cdot \pi/8$, $r=1..15$. The actual angle of rotation depends on the symbol number, at symbol no. k the angle is $k \cdot r \cdot \pi/8$.

In contrast to case (d) neither the data nor the pure PSK modulation cause any problem. Only the rotation has to be taken into account, and the rotation angle does not depend on the data but only on the position of the symbol in the sequence. The solution is to prevent the mapping from rotating at the wraparound, which can be done in the following way.

Assume the sequence length N (in numbers of symbols) is a multiple of 16 ($N=m \cdot 16$, m being an integer). Then the last symbol has the index N-1 and the rotation during the *next* transition – from symbol N-1 to symbol 0 – gives an angle of

$$\Theta = N \cdot r \frac{\pi}{8} = 16 \cdot m \cdot r \frac{\pi}{8} = m \cdot r \cdot 2\pi \qquad \text{Eq. 4.14}$$

But a rotation angle that is a multiple of 2π leads to the same result as no rotation at all: the mapping does not change. So a sequence length being a multiple of 16 ensures a smooth wraparound for all possible PSK rotation settings in WinIQSIM.

These rules are mostly useful for *continuous* modulated signals. In general *bursted* signals do not lead to wraparound problems as one designs the signal to have zero power at the beginning and the end of a sequence.

4.4 Guide to constructing multi-carrier signals

Rule 1:

First solve the modulation wraparound problem for each single carrier. Choose appropriate data and sequence length. If you are not sure, try first in single carrier mode. Also adjust oversampling and window function.

Rule 2:

Set carrier spacing according to the condition Eq. 4.12. Use the **carrier spacing assistant** for this calculation. If the frequency resolution is not good enough, increase the sequence length. (Be careful to still fulfill the conditions for modulation wraparound.)

Rule 3:

If you need different data on different carriers, try to use PRBS as the data source and activate the „**different start values for PRBS**“ option in the `carrier settings` panel. Sometimes the resulting sequence might be too long and lead to more than 4 MSamples memory required. In this case, create your own - shorter - data sources (up to three) with the data editor. If three different data sources are not enough for your application, create your own user data files. The multi carrier scenario may then be built using the `Multi Carrier Mixed Signal` system.

Rule 4:

To improve signal quality, if needed, adjust **oversampling** and **super oversampling**. If the carrier spacing is larger than the symbol rate and a single carrier with the same modulation is good, increase **super oversampling** in the `Multi Carrier` system. This improves simulation of the offset oscillations.

Rule 5:

After calculation investigate both the time signal (i(t), q(t)) and the frequency spectrum (graphics and graphic settings) [13]. If the signal quality is low, check rules 1 to 4. If this does not help, try varying one or more parameters (still according to rules 1 to 4).

Rule 6:

Avoid resampling during transmission with multi carrier scenarios. Choose „**no filter**“ in the `AMIQ --> Lowpass Filter...` menu to switch off automatic resampling according to filter characteristics. As there exist some fragile relations between the different modulation and sample parameters in multi carrier setups, use of this function may result in clock spurs in the signals. If you want to use antialiasing filters with the AMIQ, adjust oversampling, super oversampling and low pass filters manually or use appropriate external filters.

---

[13] An experimental hint: it may also be useful to investigate the I- and Q-signals coming out of the AMIQ. For this set a trigger impulse near the end of the sequence by programming one of the markers (see WinIQSIM user manual). The wraparound of the I- and Q-signals may then be examined with an oscilloscope triggered by the marker output.

4.5 Example I: Unmodulated Carriers

To get familiar with the multi carrier system of WinIQSIM we start by dealing with some setups containing only unmodulated carriers (also named CW for continous wave). This is not only a textbook situation. For example, setups with many CW carrier (40 and more) are used as a „broadband" source in amplifier testing.

Eight CW carriers with 240 kHz spacing and varying powers

Let's design a typical CW multi carrier setup for amplifier testing. To save time we will restrict ourselves to eight carriers.

Choose the **multi carrier** option in the `system` pull down menu. Then open the `data source` panel and choose **data source type PRBS** in the source selection at the top. Set this source to **PRBS 9**. Open the `carrier settings` menu and set the number of carriers to eight.

Configure the channels with the channel definition part in the middle of the panel. For all carriers set **state ON**, **modulation OFF** and **data source PRBS**. Adjust the powers of the channels in the following manner.

Channel	0	0.00 dB
	1	-30.00 dB
	2	-6.00 dB
	3	-12.00 dB
	4	-40.00 dB
	5	-15.00 dB
	6	-5.00 dB
	7	-21.00 dB

Open the `modulation` panel and set the **modulation type** to **CW (none)**. Then set the values for the **symbol rate** [14] (10000 1/s) and the **sequence length** (1000 sym). Filter function and baseband impulse depend on each other. Either set **filter function rect** / **baseband impulse Dirac** or **filter function none** / **baseband impulse rect**. The result is the same in either case. The automatic value for **baseband impulse** is **Dirac** [15]. Close the panel by clicking on the **OK** button.

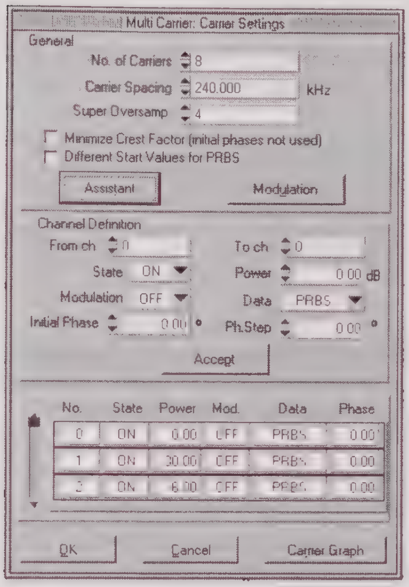
In the `carrier settings` window set the **super oversampling** factor (SOV) to 5. This will allow the use of the 2.5 Mhz reconstruction filter in the AMIQ. Now let's deal with the carrier spacing.

To manage the double wraparound problem in a convenient way use the **carrier spacing assistant** function of WinIQSIM. The assistant checks **symbol rate**, **sequence length** and desired **carrier spacing** and calculates the nearest smaller value for the spacing that leads to a smooth wraparound. Of course you may ignore the assistant and use any desired values for the parameters. But remember that violation of the rules in section 4.4 is likely to result in spurious signals.

---

[14] In a rigorous point of view a „symbol rate" makes no sense with an unmodulated carrier. But calculation requires setting the sample rate, which is done in the same way ($f_{sam} = f_{sym} \cdot OV$) as with modulated carriers. On the other hand one needs to define the duration T_{seq} of the signal to be created. T_{seq} is given by $T_{seq} = f_{sym} / n_{seq}$ with the sequence length n_{seq} in numbers of symbols.

[15] The program uses a BPSK modulation with data source „all zero" to obtain a constant value of one at I (zero at Q). The appropriate baseband impulse for PSK modulations is DIRAC.


Multi Carrier: Carrier Settings

General

No. of Carriers: 8

Carrier Spacing: 240.000 kHz

Super Oversamp: 4

☐ Minimize Crest Factor (initial phases not used)

☐ Different Start Values for PRBS

Channel Definition

From ch: 0

To ch: 0

State: ON

Power: 0.00 dB

Modulation: OFF

Data: PRBS

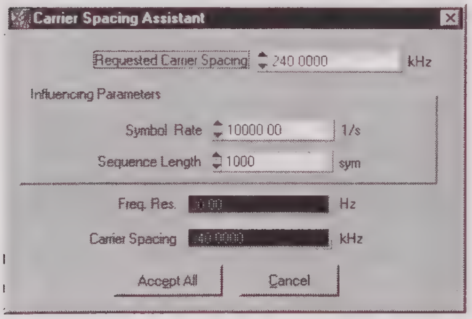
Initial Phase: 0.00 °

Ph.Step: 0.00 °

No.	State	Power	Mod.	Data	Phase
0	ON	0.00	OFF	PRBS	0.00
1	ON	30.00	OFF	PRBS	0.00
2	ON	6.00	OFF	PRBS	0.00

Fig. 4-6: *Carrier settings window for 8 CW carriers*

Open the `assistant` panel and enter 240 KHz as requested carrier spacing. Press the return key, the `assistant` panel should look like this now.


Carrier Spacing Assistant

Requested Carrier Spacing: 240.0000 kHz

Influencing Parameters

Symbol Rate: 10000.00 1/s

Sequence Length: 1000 sym

Freq. Res.: [illegible] Hz

Carrier Spacing: 240.0000 kHz

Fig. 4-7: *Settings of the assistant panel*

Click on the **accept** button. The values for **sequence length**, **symbol rate** and **carrier spacing** are adjusted automatically [16].

Open the `carrier graph` window by clicking on the **carrier graph** button. The window should look like this.

---

[16] In this case there is no need for a change of carrier spacing cause the parameters match by chance. See the next example for a worse situation.

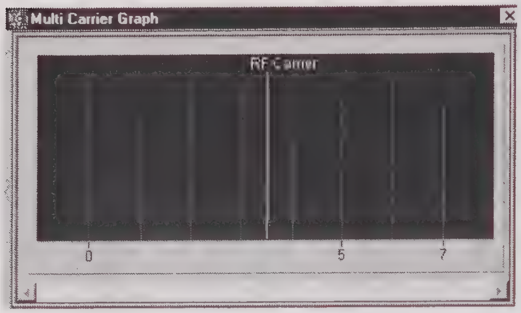


Fig. 4-8: The carrier graph window gives an overview of the multi carrier setup. Unmodulated carriers are indicated by vertical narrow red bars, modulated ones by green symbolic spectra. The relative power of the carriers corresponds to the height of the indicators.

Now click on the **graphics** icon in the icon bar to calculate the signal. Examine the frequency spectrum (**graphic setting FFT magnitude**) and the wraparound in time domain (setting **I(t), Q(t), show wraparound** option).

Also have a look at the entire I(t), Q(t) sequence. Use the **zoom** function for a detailed investigation. You will recognize distinct peaks which repeat periodically. These occur because all carriers start with the same phase. As the frequencies of the offset oscillations are all multiples of 120 kHz, there are times when all carriers add up with maximum amplitudes. This results in a high crest factor of the signal.

The crest factor of a multi carrier signal may be reduced significantly with the „**minimize crest factor**" option in the `carrier settings` panel. This function randomizes the start phases of the carrier and in that way reduces the peak value of the signal. Open the `carrier settings` panel again and turn on the „**minimize crest factor**" option. Leave the other settings unchanged and do the calculation again. The signal looks more even now [17].

You may also transmit both waveforms to AMIQ and measure the crest factors, e.g. with an FSE spectrum analyzer.

4.6 Example II: NADC Multi Carrier

(a) Ten NADC carriers with 120 kHz spacing

As a first example including modulated carriers we want to build up a scenario consisting of ten NADC modulated carriers. A typical application of such a setup would be testing amplifiers. Using the multi carrier features of WinIQSIM / AMIQ such tests can be performed with only one RF signal generator.

To approximate real conditions there should be different data on different carriers. In addition, the intermodulation performance of the signal must be as good as possible.

For the carrier spacing we choose 120 kHz, as required in some test specifications.

To solve this problem we have to deal with the double wraparound problem (due to the modulation and the offset oscillation). Further we must find a way to use different data on different carriers.

As explained in section 4.3, we ensure a smooth modulation wraparound for π/4DQPSK by repeating a certain sequence eight times. As this sequence may be arbitrarily chosen, we use twice a complete

---

[17] Numeric values of the crest factor may also be drawn out of the menu „AMIQ --> signal statistics and quantization" or the calculation of the CDF function.

PRBS 9 sequence (511 symbols). The overall sequence length is therefore 8*511 = 4088 symbols. So the function „**different start values for PRBS**“ in the `Carrier Settings` menu (with **data source PRBS**) can be used. This is the easiest way to get different data on the different carriers.

Fixing the sequence length leads to a frequency resolution of the carrier spacing according to the equation 4.12 (see section 4.2)

With

$$f_{sym} = 24300\,s^{-1}$$

$$n_{sym} = 4088$$

this gives

$$f_{seq} = 5.9442\,s^{-1}$$

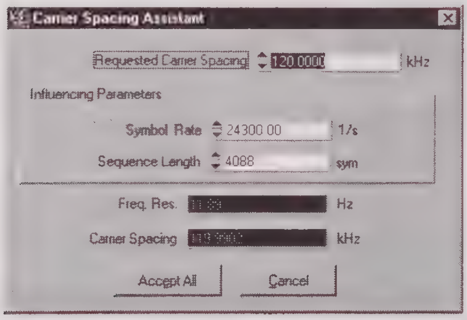
and

$$df = 11.89\,s^{-1}$$

for the frequency resolution df of the carrier spacing (remember the additional factor 2 - see Eq. 4.12). The nearest suitable value for Δf is therefore

$$\Delta f = 119.9902\,kHz$$

This value is also suggested by the **carrier spacing assistant**.


Carrier Spacing Assistant

Requested Carrier Spacing 120.0000 kHz

Influencing Parameters

Symbol Rate 24300.00 1/s

Sequence Length 4088 sym

Freq. Res. 11.89 Hz

Carrier Spacing 119.9902 kHz

Fig. 4-9: Assistant panel for setting the carrier spacing in the NADC ten carrier example

If we wanted to get closer to the desired carrier spacing we could, for instance, increase the sequence length in the appropriate field of the assistant. However, we accept the indicated settings.

Another subject of concern is the carrier feedthrough of the IQ modulator. If all carriers have an offset there are generally remains of the RF carrier left. Therefore it's better to position one of the carriers at the RF frequency to mask that carrier feedthrough. With an even number of carriers 2n this is done by using 2n+1 carriers and turning off the last one.

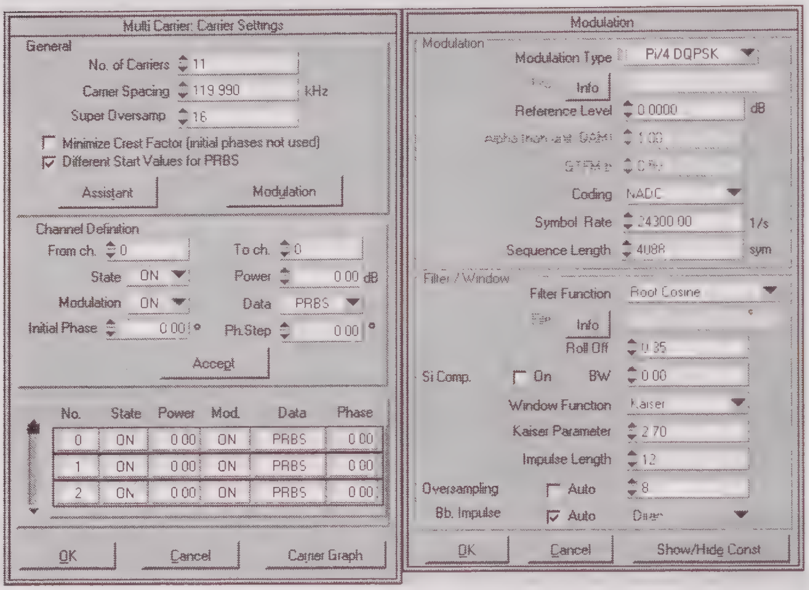
To achieve the required scenario the following settings should be made:

DATA SOURCE --> DATA SOURCE PRBS --> set to PRBS 9

CARRIER SETTINGS -->	(see Fig. 4-10)	
NO. OF CARRIERS	11	
CARRIER SPACING		
--> ASSISTANT	requested carrier spacing	120 kHz
	Symbol Rate	24300 1/s
	Sequence Length	4088 sym
	Freq res	11.89 Hz
	Carrier Spacing	119.9902 kHz
--> ACCEPT ALL		

SUPER OVERSAMPLING	16
DIFFERENT START VALUES FOR PRBS	on
CHANNEL 0-9	ON, MOD ON, DATA PRBS, POWER 0.0dB
CHANNEL 10	OFF

MODULATION --> (see Fig. 4-10)



No. of Carriers 11
Carrier Spacing 119 990 kHz
Super Oversamp 16
☐ Minimize Crest Factor (initial phases not used)
☑ Different Start Values for PRBS

From ch. 0
To ch. 0
State ON
Power 0 00 dB
Modulation ON
Data PRBS
Initial Phase 0 00 °
Ph.Step 0 00 °

No.	State	Power	Mod.	Data	Phase
0	ON	0 00	ON	PRBS	0 00
1	ON	0 00	ON	PRBS	0 00
2	ON	0 00	ON	PRBS	0 00

Modulation Type Pi/4 DQPSK
Reference Level 0 0000 dB
Coding NADC
Symbol Rate 24300 00 1/s
Sequence Length 4088 sym
Filter Function Root Cosine
Roll Off 0 35
Si Comp. ☐ On BW 0 00
Window Function Kaiser
Kaiser Parameter 2 70
Impulse Length 12
Oversampling ☐ Auto 8
Bb. Impulse ☑ Auto

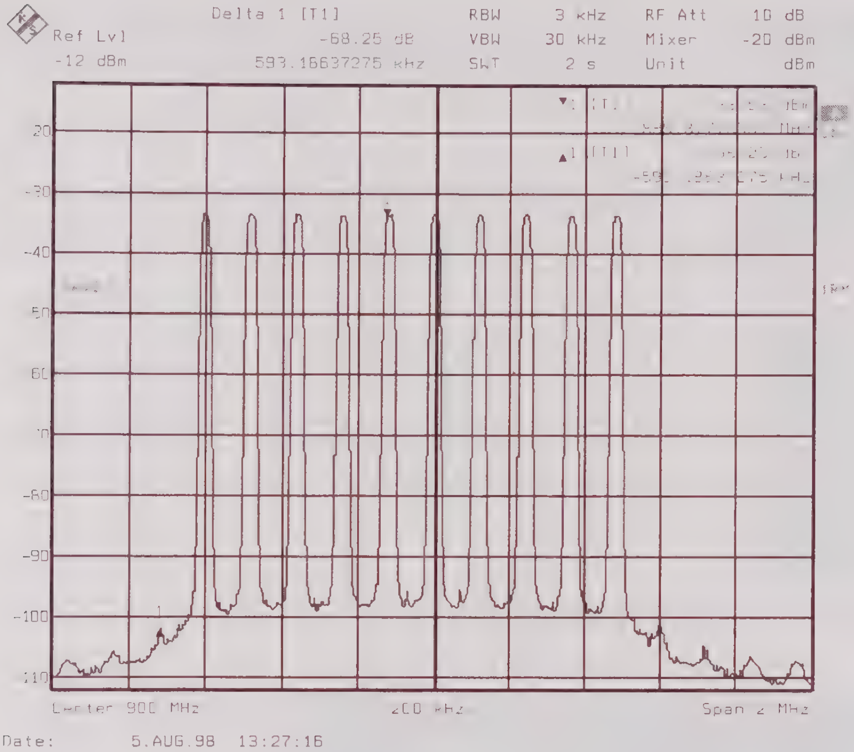
Fig. 4-10: Carrier settings (left) and modulation settings (right) for the 10 NADC carrier setup.

After setting all values, start the calculation of the waveform. This is best done just before lunch because calculation will take at least half an hour.

Examine the graphics of the created waveform. Use „**show wraparound**" in **i(t), q(t)** to investigate the wraparound of the signal. If you see any jumps or discontinuities, check if you've done every step correctly and calculate again.

If the signal appears correct, store the waveform file on your computer harddisk and/or transmit it to the AMIQ. Make sure that in **`AMIQ --> Lowpass Filter...`** menu „**no filter**" is chosen to avoid resampling during transmission. Don't worry about aliasing, the AMIQ 2.5 MHz reconstruction filter may be used anyway, due to our chosen parameter values the sampling rate is high enough.

Measuring the intermodulation performance of the signal with an FSE spectrum analyzer should lead to the results shown below. Due to the nonsymmetric carrier distribution (remember: we have 5 carriers on the left, one at RF frequency and 4 on the right) you may recognize a so-called IQ-image at the position of the (switched off) eleventh carrier. This is a remainder of the one at the far left side. Such an image can be suppressed by adding some IQ impairments. This adjustment can be done in the VECTOR MODULATION menu of the SMIQ. Try out and optimize signal performance.



Delta 1 [T1] -68.25 dB 593.16637275 kHz

Ref Lvl -12 dBm

RBW 3 kHz

VBW 30 kHz

SWT 2 s

RF Att 10 dB

Mixer -20 dBm

Unit dBm

Center 900 MHz 200 kHz/ Span 2 MHz

Date: 5.AUG.98 13:27:16

Fig. 4-11: *FSE screenshot of the ten NADC carrier setup described in this subsection (using the RMS detector).*

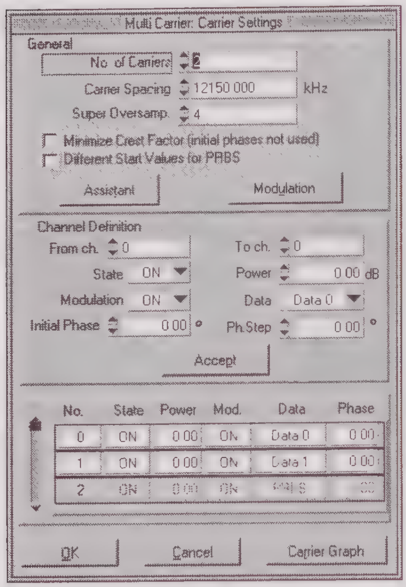
(b) Two NADC carriers with 12.15 MHz spacing

The next example is creating two carriers with rather wide carrier spacing. We want to greatly increase the spacing and achieve still very good signal quality. Therefore we first shorten the sequence. This decreases the number of samples needed for a multicarrier setup.

As we have only two carriers now, we do not need more than two different data sources. It is not much work to create these with the data editor. Open the `data editor` panel and create two data fields of length 50 symbols, one with PRBS 9, the other with PRBS 11. Continue with building a slot for carrier 0 by stringing together the PRBS 9 data field eight times. Then build a slot for carrier 1 with eight times the PRBS 11 data field.

Create a frame consisting of slot carrier 0 and store the sequence as a file (e. g. named NA2C_CAR0.DBI), then the same for carrier 1 (NA2C_CAR1.DBI).

If we don't change the modulation parameters and use a super oversampling factor of 4 the maximum possible carrier spacing would be about 24 MHz (which stresses the DAC of the AMIQ somewhat, so that the intermodulation products begin to raise). As the sequence length is now 400 symbols, the frequency resolution for the carrier spacing reads 121.5 Hz. A good choice for Δf is then Δf = 12.15 MHz. This provides a setup with wide spacing and still very good signal quality. The carrier settings should look like this:


Multi Carrier: Carrier Settings

General

No. of Carriers 2

Carrier Spacing 12150.000 kHz

Super Oversamp. 4

☐ Minimize Crest Factor (initial phases not used)

☐ Different Start Values for PRBS

Channel Definition

From ch. 0

To ch. 0

State ON

Power 0.00 dB

Modulation ON

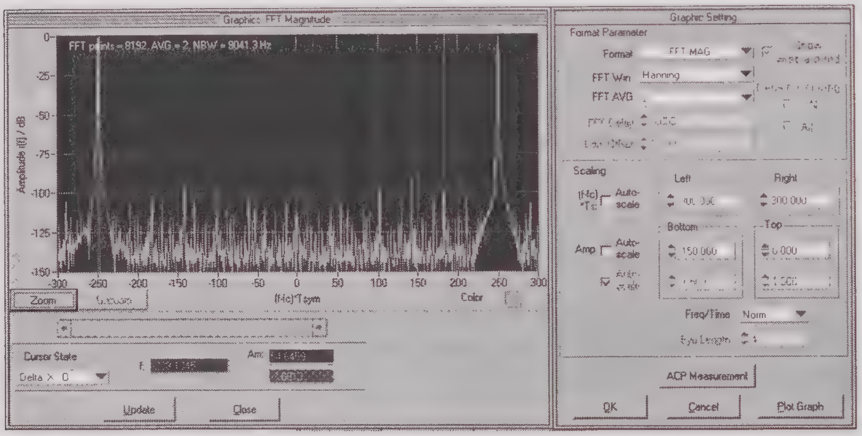
Data Data 0

Initial Phase 0.00 °

Ph.Step 0.00 °

No.	State	Power	Mod.	Data	Phase
0	ON	0.00	ON	Data 0	0.00
1	ON	0.00	ON	Data 1	0.00
2	ON	0.00	ON	[illegible]	[illegible]

Fig. 4-12 Carrier settings of 2 NADC with 12.15 MHz spacing



Format FFT MAG

FFT Win Hanning

(f-fc)*Ts: ☐ Auto-scale

Right 300.000

Amp ☐ Auto-scale

Bottom -150.000

Top 0.000

Freq/Time Norm

Fig. 4-13: Spectrum (FFT magnitude) of the two NADC carrier multi carrier setup described above (left) and related graphics settings in WinIQSIM (right).

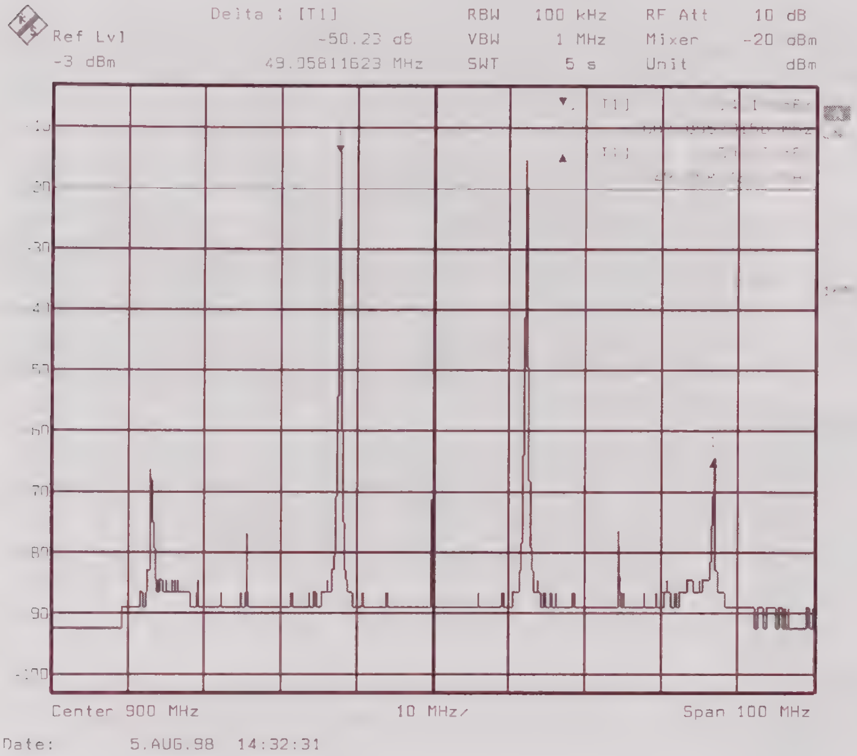
Calculation of the waveform and transmission to AMIQ works in the same way as in the previous examples. Again make sure that the automatic resampling function for transmission is turned off. An FSE screenshot of this signal is shown in Fig. 4-14.

Finally we should say a few words about *optimizing signal quality*. The parameters to play with are in general oversampling (OV), super oversampling (SOV) and overall sample rate. If the carrier spacing is large against the modulation frequency - like in these examples - the modulation is the envelope of the time signal and varies slowly. Then the oversampling factor won't be very significant for building the fast oscillation and the recommended values (**auto** settings in WinIQSIM) should be sufficient in most cases [18]. The most important parameters are then SOV and overall clock rate. Higher SOV values give better looking signals and better signal-to-noise ratios. On the other hand, clock rates near 100 MHz stress the AMIQ hardware which leads to significant intermodulation products. As general advice, one should stay below 60 MHz and use maximum SOV inside that range to obtain best intermodulation performance.

---

[18] If the carrier spacing and the carrier bandwidth are nearly equal, the influence of OV and SOV on the entire signal cannot be clearly distinguished.

For broadband signals (e.g. W-CDMA carriers placed next to each other) where the broadband noise of the used signal generator might be the most important factor for signal quality, clock rates up to 80-90 MHz will produce satisfactory results.



```
          Delta 1 [T1]          RBW   100 kHz   RF Att    10 dB
Ref Lvl          -50.23 dB      VBW     1 MHz   Mixer    -20 dBm
-3 dBm     49.05811623 MHz      SWT       5 s   Unit        dBm

Center 900 MHz                  10 MHz/             Span 100 MHz
Date:        5.AUG.98   14:32:31
```

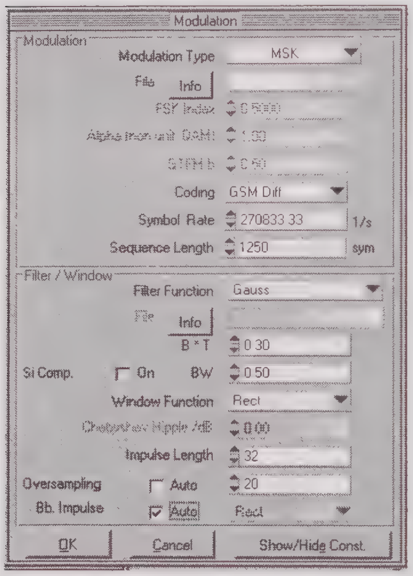
Fig. 4-14: FSE screenshot of the two NADC carrier setup with 12.15 MHz carrier spacing.

In spite of the numerous feasibilities of the **`Multi Carrier`** system, there remains one restriction. It is not possible to use different modulation settings on different carriers. This restriction applies to different modulation types on different carriers (for example GSM and NADC) as well as to different burst structures (varying powerramping). Furthermore, the **`Multi Carrier`** system does not support CDMA and WCDMA because these are systems in their own. For instances like these, the **`Multi Carrier Mixed Signal`** system was designed.

4.7 Example III: GSM bursted multi carrier using Multi Carrier Mixed Signal system

As an example for a complex multi carrier scenario we will design two GSM carriers bursting in different timeslots. The procedure for this is the following. We will create the first carrier and save it in the .IBN format (**save for add / Multi Carrier Mixed Signal** function in the `File` pull down menu), then build and save the second carrier. The entire scenario is designed in the `Multi Carrier Mixed Signal` system.

First step is to create a GSM frame data source for the first carrier. We may use the example files delivered with WinIQSIM. Open the WinIQSIM setting GSM_SLO1.IQS in the WINIQSIM\EXAMPLES folder. (This is a setting of the `single carrier` type.) Then open the `data editor` panel and load the configuration file GSM_TSC1.DED. This contains a library of GSM data fields and slots. The frame setting is a normal burst in timeslot 1, with all other timeslots off. Save this sequence as GSM_CAR1.DBI and your data editor setting as GSM_CAR1.DED.



Modulation
Modulation Type: MSK
File
FSK Index: 0.5000
Alpha (nominal GAM): 1.00
GTFM b: 0.50
Coding: GSM Diff
Symbol Rate: 270833.33 1/s
Sequence Length: 1250 sym

Filter / Window
Filter Function: Gauss
File
B * T: 0.30
Si Comp. ☐ On BW: 0.50
Window Function: Rect
Chebyshev Ripple /dB: 0.00
Impulse Length: 32
Oversampling ☐ Auto 20
Bb. Impulse ☑ Auto Rect

Fig. 4-15: Modulation settings for the first GSM carrier

Now create the first GSM carrier: Choose FILE: GSM_CAR1.DBI as **data source** and check the `modulation settings` (see Fig. 4-15).

Calculate the waveform and check for discontinuities, especially at the borders of the bursts. Then save the waveform using the „**save for add / Multi Carrier Mixed Signal**“ function in `File` menu. Name the waveform GSM_CAR1.IBN and save your setting (for security) as GSM_CAR1.IQS.

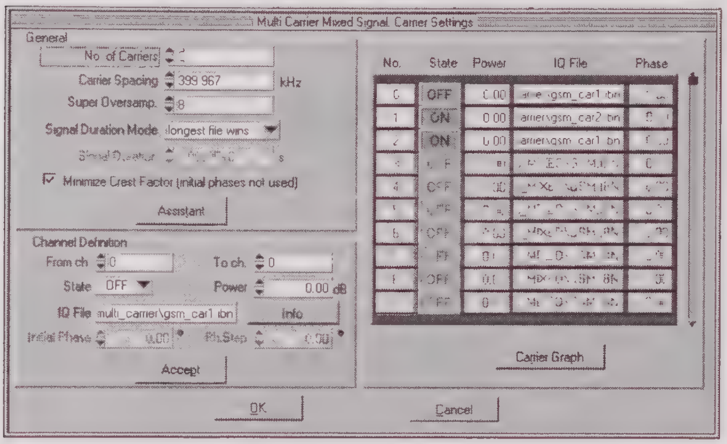
Open the `data editor` again (File GSM_CAR1.DED) and build a new frame by replacing the **NOR1** slot with a (grey) **156** dummy slot and putting a **NOR5** slot in timeslot 5. Calculate and save this sequence as GSM_CAR2.DBI (and your data editor setting as GSM_CAR2.DED just in case).[19]

Change the data source to FILE: GSM_CAR2.DBI and calculate the waveform. Save the waveform in the .IBN format (as GSM_CAR2.IBN) and the setting as GSM_2CAR.IQS for reuse.

---

[19] In this case it makes no sense to calculate all data sources in advance, because the powerramping settings are not saved with the file

Now open a new setting (`File --> New...`), choose `Multi Carrier Mixed Signal` as system and open the `Carrier Settings` panel. As in the previous examples we want to put one of the carriers on the RF frequency. Therefore set the number of carriers to three and switch off the first carrier. Choose the file sources for the carriers: GSM_CAR2.IBN for the second, GSM_CAR1.IBN for the third carrier. So the signal with the burst in timeslot 5 is on the RF frequency, the signal with burst in timeslot 1 is placed on the right. The carrier spacing shall be 400 kHz. Choose „**longest file wins**" for the **signal duration mode** and set the **carrier spacing** using the **carrier spacing assistant** (see Fig. 4-16 for the entire carrier settings). Then calculate the waveform.


Multi Carrier Mixed Signal Carrier Settings

General

Carrier Spacing 399.967 kHz

Super Oversamp. 8

Signal Duration Mode longest file wins

☑ Minimize Crest Factor (initial phases not used)

Channel Definition

From ch 0 To ch. 0

State OFF Power 0.00 dB

IQ File multi_carrier\gsm_car1.ibn

No.	State	Power	IQ File	Phase
0	OFF	0.00	gsm_car1.ibn	
1	ON	0.00	arrier\gsm_car2.ibn	
2	ON	0.00	arrier\gsm_car1.ibn	

Fig. 4-16: Carrier settings in Multi Carrier Mixed Signal system for the two GSM carrier example.

The time representation of the resulting signal is shown in Fig. 4-17. Check again for discontinuities in the signal and transmit the waveform to AMIQ or store it on your computer. Save the setting as GSM_2CAR_MIX.IQS for reuse.

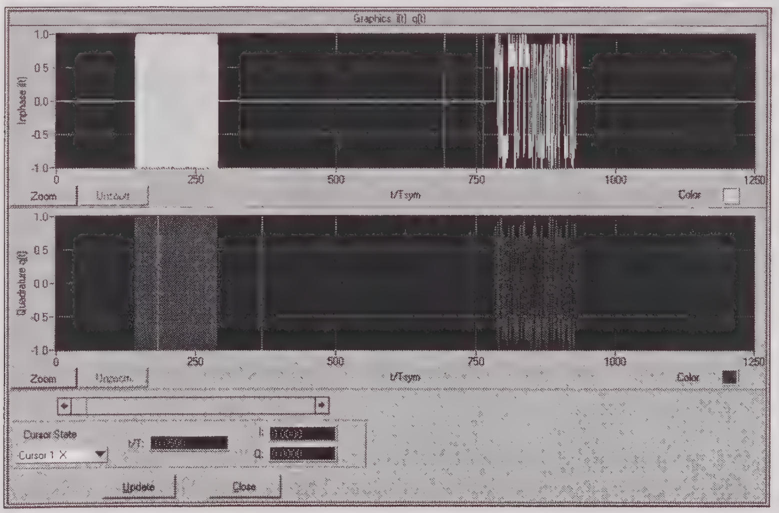
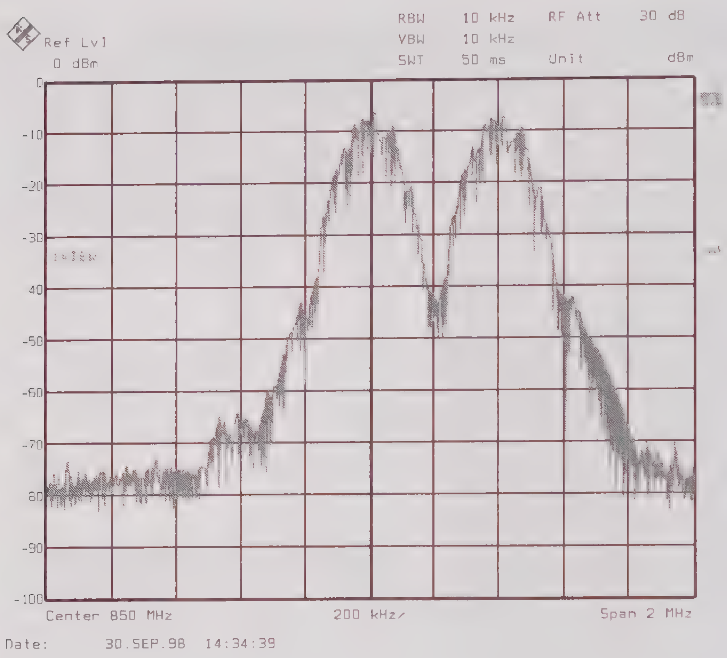


Fig. 4-17: Time representation of the 2 GSM carrier setup. The first burst is related to carrier 1, the second one to carrier 2. Carrier 2 has no offset with respect to the RF frequency and therefore oscillates less quickly.



```
                              RBW    10 kHz   RF Att    30 dB
  Ref Lvl                     VBW    10 kHz
   0 dBm                      SWT    50 ms    Unit        dBm

  Center 850 MHz              200 kHz/                Span 2 MHz
Date:      30.SEP.98   14:34:39
```

Fig. 4-18: Screenshot of the frequency spectrum of the GSM 2 bursted carrier signal, captured with an FSE spectrum analyzer using MAX HOLD function.

4.8 Example IV: W-CDMA multi carrier using Multi Carrier Mixed Signal system

As a second example for the `Multi Carrier Mixed Signal` system we will design a W-CDMA multi carrier signal. As you need some knowledge about W-CDMA signals, it is essential to study the W-CDMA part of the WinIQSIM user manual first.

Anyway, our aim in this section is to generate a setup of two W-CDMA carriers with 10 MHz spacing. The general procedure is similar to the one in the previous section. Generate the two carriers separately with the `W-CDMA` system and save the waveforms in .IBN format (**Save for add / Multi Carrier Mixed Signal**). Then generate the multi carrier setup using the `Multi Carrier Mixed Signal` system.

For the carriers we will use two example settings that are delivered with WinIQSIM. You also may design your own channel and data configuration for each channel. If you need more information to do this, read chapter 8 of the WinIQSIM user manual.

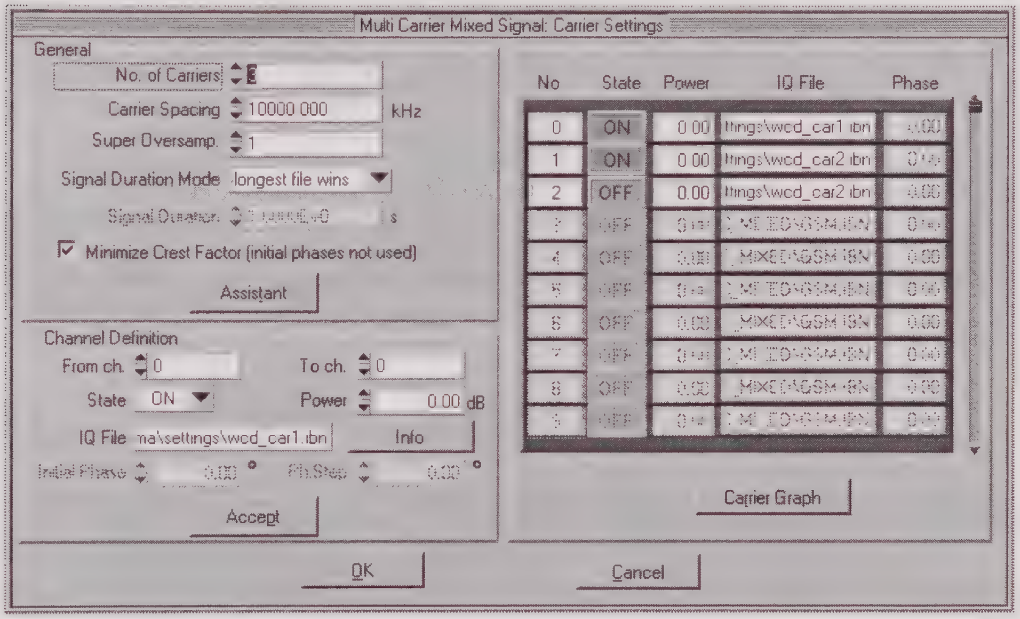
Let's create the first carrier. Open the settings file 15DPCHA.IQS in the EXAMPLES\WCDMA folder. This is a downlink W-CDMA setup with 15 dedicated physical channels. The data in different channels are not correlated. On the other hand the channels have no data or longcode offset, therefore all channels contain the same pilot symbols appearing at the same time. This is a setup which leads to a rather high crest factor. (See WinIQSIM user manual chapter 8 for further explanation.)

Open the W-CDMA configuration panel and change the oversampling factor to 8. This increases the quality of the modulated single carrier W-CDMA signal. Calculate the CCDF (complementary cumulative distribution function) by clicking on the CDF Test button. Then calculate the signal and check the wraparound. Save the signal as WCD_CAR1.IBN (**Save for add / Multi Carrier Mixed Signal**) and your setting.

Load the example setting 15DPCHAO.IQS which gives a channel configuration with data offset and therefore a distinctly smaller crest factor. Again change the oversampling to 8, calculate the CDF and the waveform. Save the waveform file as WCD_CAR2.IBN and the setting.

Load a new `Multi Carrier Mixed Signal` setting and open the `carrier settings` panel. Set the number of carriers to three and switch off the third one. Then the second carrier is placed on the RF frequency to mask the IQ feedthrough of the SMIQ I/Q modulator. Choose WCD_CAR1.IBN and WCD_CAR2.IBN as IQ files for the first two channels. Complete the settings as shown in Fig. 4-19 and set the carrier spacing using the **carrier spacing assistant**.

Calculate the CDF and the resulting signal. Don't forget to save your results.



No. of Carriers 3
Carrier Spacing 10000.000 kHz
Super Oversamp. 1
Signal Duration Mode longest file wins
Signal Duration [illegible] s
☑ Minimize Crest Factor (initial phases not used)

From ch. 0 To ch. 0
State ON Power 0.00 dB
IQ File na\settings\wcd_car1.ibn
Initial Phase 0.00 ° Ph.Step 0.00 °

No	State	Power	IQ File	Phase
0	ON	0.00	ttings\wcd_car1.ibn	0.00
1	ON	0.00	ttings\wcd_car2.ibn	0.00
2	OFF	0.00	ttings\wcd_car2.ibn	0.00
3	OFF	0.00	_MIXEDGSM.IBN	0.00
4	OFF	0.00	_MIXEDGSM.IBN	0.00
5	OFF	0.00	_MIXEDGSM.IBN	0.00
6	OFF	0.00	_MIXEDGSM.IBN	0.00
7	OFF	0.00	_MIXEDGSM.IBN	0.00
8	OFF	0.00	_MIXEDGSM.IBN	0.00
9	OFF	0.00	_MIXEDGSM.IBN	0.00

Fig. 4-19: Carrier settings in Multi Carrier Mixed Signal for the W-CDMA two carrier example.

5 BER measurements with WinIQSIM and AMIQ

5.1 Overview

The I/Q modulation generator AMIQ with option AMIQ-B1 can measure bit error rates (BER) for user data consisting of a PRBS sequence. The data is decoded by the device under test (DUT) and forwarded to the AMIQ BER tester, which synchronizes to the known PRBS sequence and counts the bit errors. For generating and checking the PRBS a feedback shift register is used.

This method has two major advantages. First, the bit error detector only requires the calculation algorithm, not the total sequence. Second, the analysis can be started anywhere in the bit stream, as the shift register synchronizes itself to the sequence at the beginning of the measurement.

This chapter describes the principle of the bit error rate test with AMIQ / WinIQSIM and provides two example setups demonstrating the capabilities of the AMIQ-B1. One demo setup is for stand-alone demonstration and uses only WinIQSIM and AMIQ, the second uses an FSE spectrum analyzer as the device under test, and can easily be adapted to real test environments.

Remark: This chapter has also been released as a separate Rohde & Schwarz Application Note (R&S Application Note 1GP36_0E).

5.2 BER measurement setups

Two setups are possible: the clock signal for the system (and possibly trigger signals) can be provided either by the DUT itself, or by AMIQ. In the first case the BER test is performed independently of the signalling part and the setup is quite simple.

Clock provided by DUT

The BER test is performed independently of the signalling part. The desired waveform can be calculated with WinIQSIM and loaded into AMIQ[20]. The D/A converted signal is then applied to the SMIQ I/Q modulator, the RF signal is forwarded to the DUT, which demodulates the received source bits and returns them to AMIQ's BER tester input together with a transfer clock. In the AMIQ BER tester, the data bits are checked for errors. The total of the transmitted bits and the faulty bits are counted. The quotient of error bits / total bits is the bit error rate. If the data stream also contains parts not to be counted (such as headers or guard bits) the AMIQ BER tester may also be controlled via its mask input by sending a data enable trigger signal from the DUT (see Fig. 5-1).

Clock provided by AMIQ

The signal has to be calculated with WinIQSIM. In addition to the data, WinIQSIM can generate appropriate trigger signals for clock, data enable and restart. The trigger signals are sent via the AMIQ marker outputs (see Fig. 5-2). To compensate for the delay in the signal path, the markers can be shifted with reference to the I/Q output signal. A coupling of the clock reference between AMIQ and SMIQ may be necessary to keep data signal and control signal paths synchronized.

---

[20] As the transmitter part of the setup and the BER tester are independent of each other, one could also use the SMIQ internal coder (-B10+-B11 options) as the data source in this case.

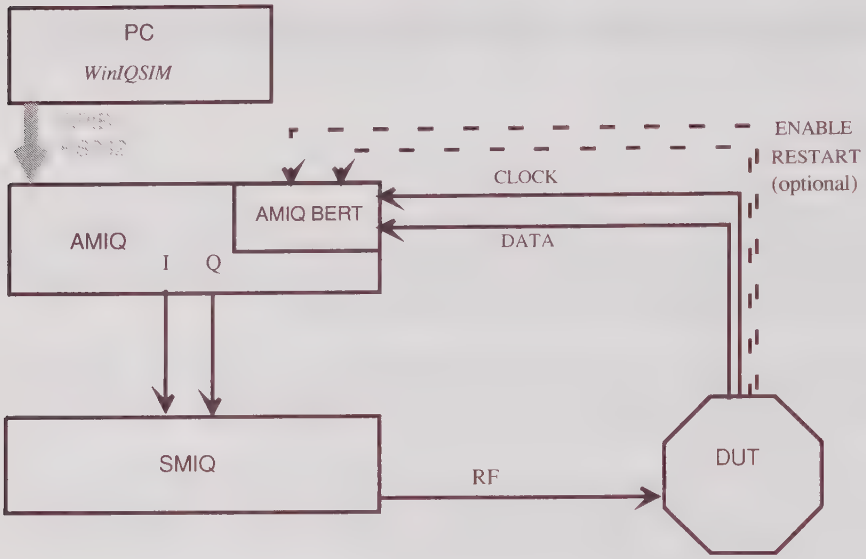


Fig. 5-1: BER test setup: clock provided by DUT

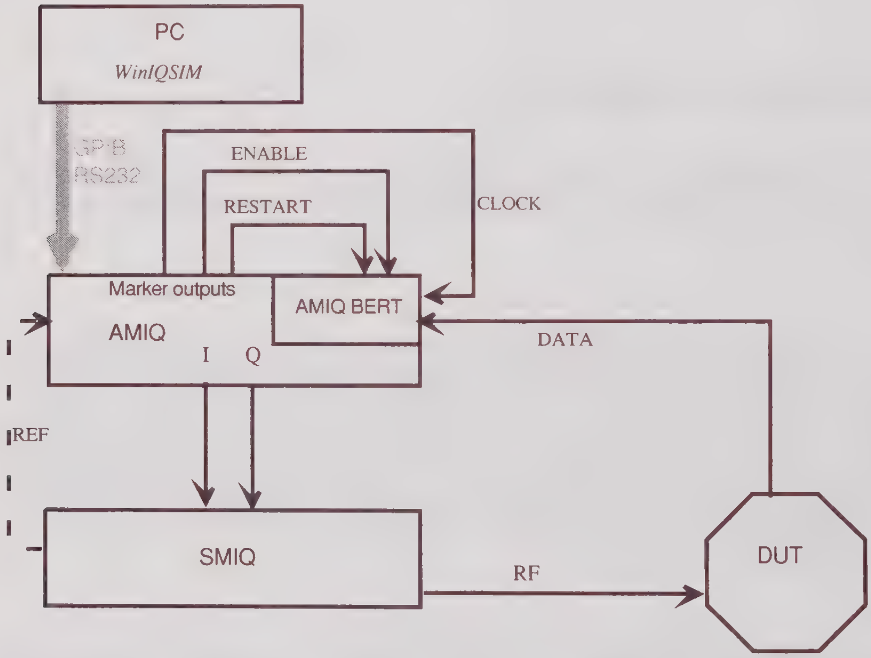


Fig. 5-2: BER test setup: clock, data enable and restart provided by AMIQ

5.3 A typical application: BER measurements with new TDMA standards

With WinIQSIM installed on a PC used in conjunction with AMIQ-B1, full control of BER measurement is provided by the PC, including setting up specialized BER tests. This is especially useful for TDMA systems still under development. WinIQSIM can create the appropriate TDMA signal structure and, in addition, program all the necessary control signals to perform a BER measurement with the signal. This section describes the principles, two examples follow in the sections 4 and 5.

First the appropriate signal has to be calculated with WinIQSIM. A typical TDMA timeslot structure in a data stream is shown in Fig. 5-3. The timeslot consists of a header, an access pattern, a user data part and some guard bits. The bit error rate need only be measured for the user data, the other parts of the timeslot do not have to be counted.

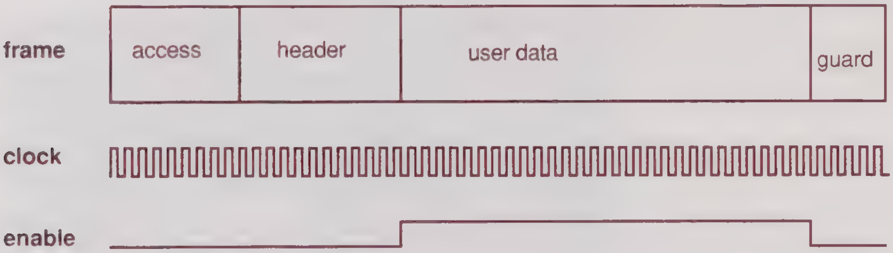
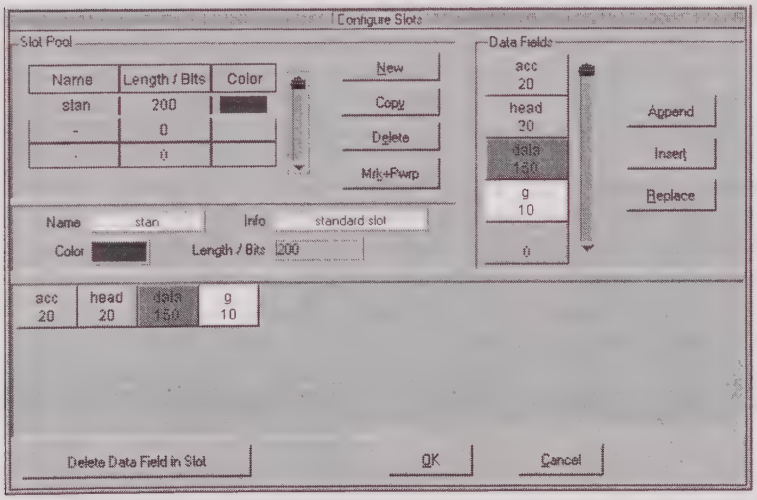


Fig. 5-3: Typical timeslot structure of a TDMA system and appropriate clock and data enable signals.



Name	Length / Bits	Color
stan	200	■
-	0	
.	0	

Name stan

Info standard slot

Length / Bits 200

Data Fields: acc 20 | head 20 | data 150 | g 10 | 0

acc 20	head 20	data 150	g 10

Fig. 5-4: Realization of the timeslot from Fig. 5-3 in WinIQSIM

Such a timeslot structure can be created with the WinIQSIM data editor. (Fig. 5-4 shows a timeslot with the four data fields access, header, user data and guard.) Access, header and guard consist of bit patterns specified for the TDMA system. The user data field is filled with BERT-PRBS data, a PRBS-like data sequence to be counted by the BER tester. Three of the four marker outputs can be programmed automatically with appropriate bit clock, data enable and restart signals:

- The bit clock is set according to the modulation rate of the system.

- The data enable signal has high level whenever data is of type BERT-PRBS and otherwise low level. The signal is fed into the data enable input of the BER tester.
- In the enable mode, the BER tester counts whenever enable input is at high level.

The modulation parameters, such as modulation rate and baseband filtering, can be programmed by WinIQSIM.

Two additional issues have to be taken into account. Generally a user data field is not long enough to store a complete PRBS sequence. If, for example, the data field contains 150 bits, more than 3 timeslots are required to accomodate a complete PRBS9 sequence (511 bits). Furthermore the timeslot structure and the PRBS length do not match. Then a continuous PRBS must be generated and correctly distributed to the timeslots (see Fig. 5-5). WinIQSIM provides continuous PRBS mode automatically with the BER test feature.

Titel
E:\TEXTE\MANUAL\WIQS_A~1\BILDER\KAP5\BERT5.EPS
Erstellt von
ImageMark Software Labs
Vorschau:
Diese EPS-Grafik wurde nicht gespeichert
mit einer enthaltenen Vorschau
Kommentar
Diese EPS-Grafik wird an einen
PostScript-Drucker gedruckt, aber nicht
an andere Druckertypen

Fig. 5-5: Distributing a PRBS 9 sequence to the user data fields of sucessive timeslots

As the AMIQ is an arbitrary waveform generator, it continuously repeats a sequence of finite length. This length is limited by the memory of the AMIQ (4 MSamples). With a typical oversampling factor of 8 the maximum number of symbols would be 500,000. In most cases the PRBS sequence will not fit in the overall sequence length, and this causes a break in the PRBS pattern. Repeating the same data sequence requires restarting the PRBS „generation“ and informing the BER tester with a restart signal.

In this setup the data signal is coupled to the clock and trigger signals. As the DUT always causes a time delay, the marker channels have to be shifted with respect to the I/Q signal. The actual delay is set by controlling AMIQ hardware, either from WinIQSIM or from SMIQ. The delay can easily be checked with an oscilloscope.

5.4 Example : BER test stand-alone demonstration setup

Real BER measurements are performed with the device under test receiving the modulated RF signal and giving back the demodulated digital data. For demonstrating the BER test capabilities of AMIQ / WinIQSIM, however, there is no need for a DUT. (This is a benefit in that a DUT may not be available.) The BER test functions can be demonstrated using just WinIQSIM and AMIQ.

To prepare the demonstration we will first build an example TDMA structure with the data editor.

TDMA structure for BER measurement

Suppose that the TDMA signal to be used has the following simple structure: a 20-bit header, a 150-bit user data field and a 10-bit guard closing the timeslot.

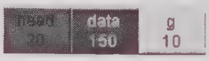
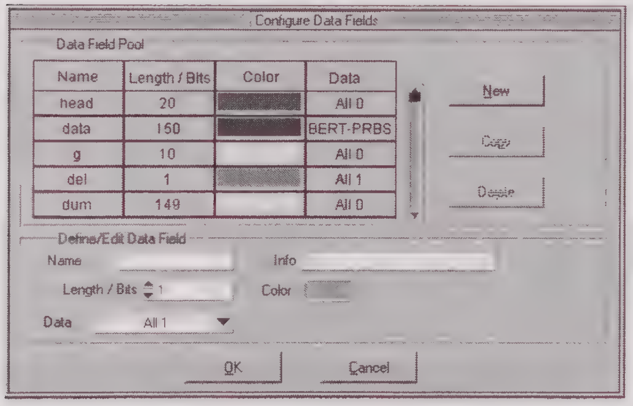


Fig. 5-6: Structure of the TDMA signal used for the BER demonstration

From the `data editor` open the data field panel. Create the three data fields. Use **all zero** as data for the header and the guard bits. For the user data choose data type **BERT-PRBS**.

We create three additional data fields which we need later for calibrating a BER test setup with a „real" DUT. Build a data field (called „**del**" or similar) containing a single **one** and another one with 149 **zeroes**. We also need a dummy field with 180 **zeroes**. The data field pool should look like this:


Configure Data Fields

Data Field Pool

Name	Length / Bits	Color	Data
head	20	▨	All 0
data	150	■	BERT-PRBS
g	10		All 0
del	1	▨	All 1
dum	149		All 0

Define/Edit Data Field

Name

Info

Length / Bits 1

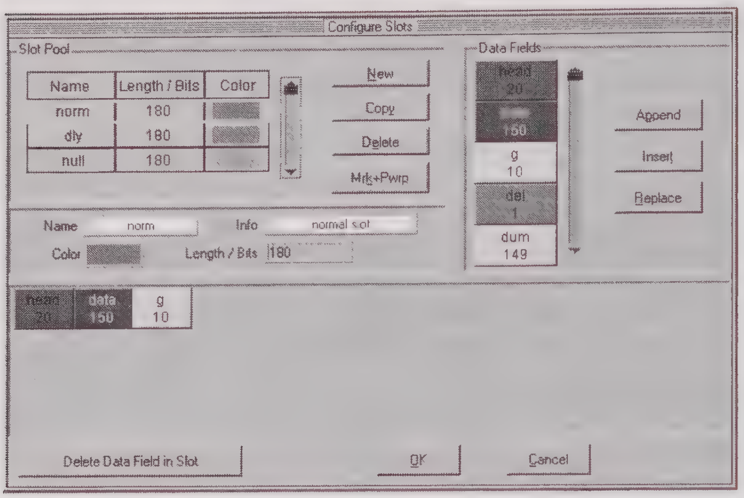
Color

Data All 1

Fig. 5-7: Data fields used for the BER test demonstration. An additional dummy data field with 180 zero bits is not shown in the figure.

Now open the slot panel and build three different slots, all 180 bits long.

- First, the „normal slot" **norm** of our TDMA system containing header, user data and guard. The second slot - called **dly** - is build from header, **del** field, the 149 **zeroes** field and again the guard. This slot contains overall **zeroes** except for a single **one** at the 21st bit. Open the marker settings panel for this slot and set a **ramp up down** signal for marker 4. Ramp up should be at position 20 (this is the 21st bit as position counter starts at 0), ramp down at position 21. Then marker 4 is at high level exactly where the data bit **one** occurs.
- The third slot consists of the **dummy** field and has only **zeroes**.



Name	Length / Bits	Color
norm	180	▨
dly	180	▨
null	180	

Name: norm
Info: normal slot
Color: ▨
Length / Bits: 180

Data Fields: head 20; [illegible] 150; g 10; del 1; dum 149

head 20 | data 150 | g 10

Fig. 5-8: *Slots used for the BER test demonstration. The structure of the normal slot is indicated in the lower part of the panel.*

This is the pool of data fields and slots we will use for the rest of this chapter. To keep it, save the data editor settings as BER_TEST.DED.

Before calculating the whole data sequence and adjusting the BER test settings we have to set the modulation parameters, as these affect the marker settings used for BER measurement.

Settings for stand-alone demonstration

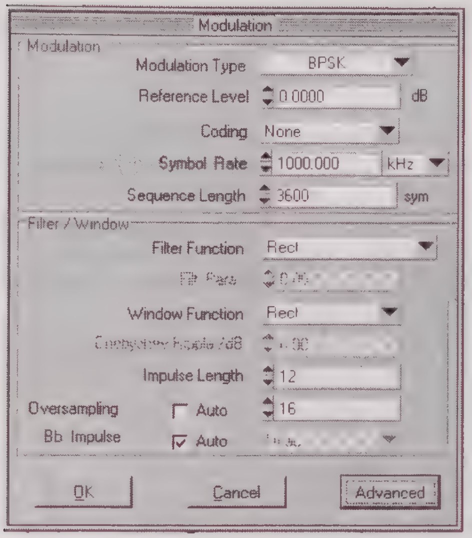
For this simple demo setup we will use the AMIQ I output as data source for the BER test. Then we need a signal at the I output resembling a digital data stream of ones and zeroes. This can be realized using a **BPSK** modulation with filter type **rect**. The **data polarity** of the BER tester has then to be set to **inverted** to identify **one** with high level and **zero** with low level.

The modulation symbol rate must match the hardware limitations (maximum clock rate of the BER tester is 20 MHz). We set the symbol rate to 1 MHz and the oversampling to 16. The entire parameter values of the `modulation settings` panel are shown in Fig. 5-9.

Back in the `data editor` complete the data and BER test settings. Open the `BERT settings` panel in the data editor and activate all control signals:

- **data enable** on marker 1
- **clock** on marker 2
- **restart** on marker 3.

Set **BERT PRBS** type to **PRBS 9** and switch on the **BERT mode**.

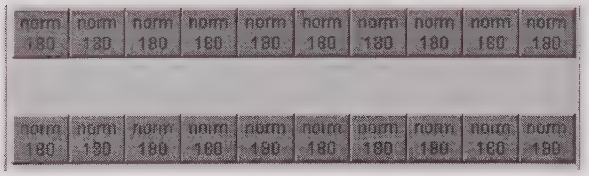

Modulation

Modulation
Modulation Type: BPSK
Reference Level: 0.0000 dB
Coding: None
Symbol Rate: 1000.000 kHz
Sequence Length: 3600 sym

Filter / Window
Filter Function: Rect
Window Function: Rect
Impulse Length: 12
Oversampling ☐ Auto 16
Bb Impulse ☑ Auto

Fig. 5-9: Modulation parameters for stand-alone demonstration

Now build a frame containing 20 of the **norm** slots. This sequence is 3600 bits long, 3000 of them are user data bits to be counted. Calculate and save the sequence as BER_SELF_TEST.DBI. The data sequence is then stored into this file and the marker channels are programmed with the control signals **enable**, **clock** and **restart** for the BER measurement. At this point it is a good idea to save the WinIQSIM settings (including the current marker parameters) as BER_SELF_TEST.IQS.



norm 180	norm 180	norm 180	norm 180	norm 180	norm 180	norm 180	norm 180	norm 180	norm 180
norm 180	norm 180	norm 180	norm 180	norm 180	norm 180	norm 180	norm 180	norm 180	norm 180

Fig. 5-10: A frame containing 20 normal slots gives the data sequence BER_SELF_TEST.DBI for the BER test stand-alone demo.

Calculate the signal and transmit it to AMIQ. Check the marker settings in the menu `AMIQ --> marker settings...` At the top of the panel the messages „**defined by data editor**" and „**BERT mode**" should appear.

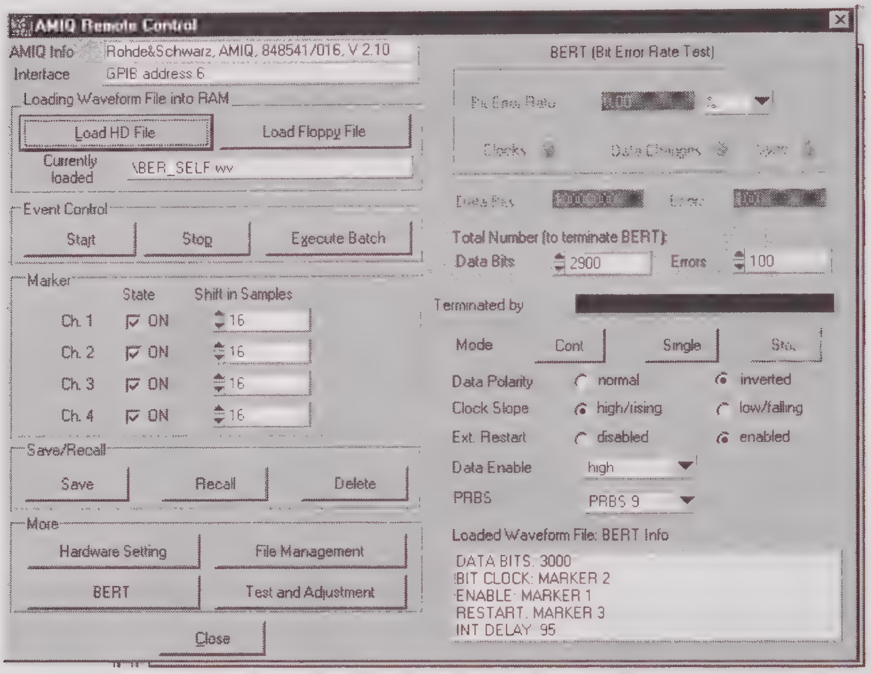
To connect the AMIQ BER tester you need the appropriate adaptor cable. Connect **data** to the I output of the AMIQ and **mask** (=**enable**) / **clock** / **restart** to the marker outputs 1 / 2 / 3.

Open the `AMIQ --> remote control and BERT...` menu. Choose `hardware settings` and set the I output to **VAR mode** and maximum level (1 V). Close the `hardware settings` panel, now you are back in `remote control and BERT`. Open the `BERT` panel and set the parameters as shown in Fig. 5-11.

The number of enabled data bits is shown in the file info box on the bottom of the panel (here: 3000). The total number of bits to be counted is set to a slightly smaller value here to avoid restarting before a single measurement is finished. To obtain good statistics in one single measurement, make the waveform sequence as long as possible. The data polarity has to be set to **inverted**.
Now start the BER test in **single** mode and check the bit error rate. As we have pure PRBS as enabled data, the bit errors should count zero. If some errors are detected there may be a small delay on the

signal path with respect to the markers. Try shifting the markers by 16 samples (= 1 symbol). If the bit error rate increases, shift in the other direction. Set the marker shift values so that the bit error rate is zero.

If AMIQ cannot synchronize or the error reads about 50%, the data signal might be received at the same time as the edge of the clock signal (means, data and clock are shifted half a symbol with respect to each other). Then shift the clock signal (marker 2) by a few samples.



AMIQ Info: Rohde&Schwarz, AMIQ, 848541/016, V 2.10
Interface: GPIB address 6
Currently loaded: \BER_SELF wv

Marker

	State	Shift in Samples
Ch. 1	☑ ON	16
Ch. 2	☑ ON	16
Ch. 3	☑ ON	16
Ch. 4	☑ ON	16

Total Number (to terminate BERT):
Data Bits: 2900 Errors: 100

Data Polarity: ○ normal ● inverted
Clock Slope: ● high/rising ○ low/falling
Ext. Restart: ○ disabled ● enabled
Data Enable: high
PRBS: PRBS 9

Loaded Waveform File: BERT Info

```
DATA BITS. 3000
BIT CLOCK: MARKER 2
ENABLE· MARKER 1
RESTART. MARKER 3
INT DELAY  95
```

Fig. 5-11: AMIQ BER test settings for the stand-alone demonstration.

Creating a data source with bit errors

So far, the data source does not contain any errors. This might be not the best way to show the capabilities of a bit error rate tester. So we continue by creating a data source containing errors.

Close the AMIQ control panel(s), but leave the hardware settings unchanged. Open the data editor (BER_SELF_TEST.DED) and calculate the same sequence again, but save it as a different file (BER_ERROR.DBI). Load this data sequence file into an ASCII text editor and change the bits #299 and #300 (from one to zero or vice versa). These are two user data bits from the second timeslot in the sequence. Do not close WinIQSIM in between, so as not to lose the marker settings and the data source file path. At least save the WinIQSIM settings.

Save the modified file, exit the ASCII editor and return to WinIQSIM. Calculate the waveform with the modified sequence as data source and transmit it to the AMIQ. A BER measurement should deliver 2 errors now instead of 0.

5.5 Example: BER test demo setup with FSE as device under test

Test setup

It is also possible to show the BER test features of AMIQ / WinIQSIM in a „real" test setup by using an FSE spectrum analyzer as the demodulating unit. This application is described in a Rohde & Schwarz application note (1MA16_0E) written by Roland Minihold. The test setup used is shown in Fig. 5-12.

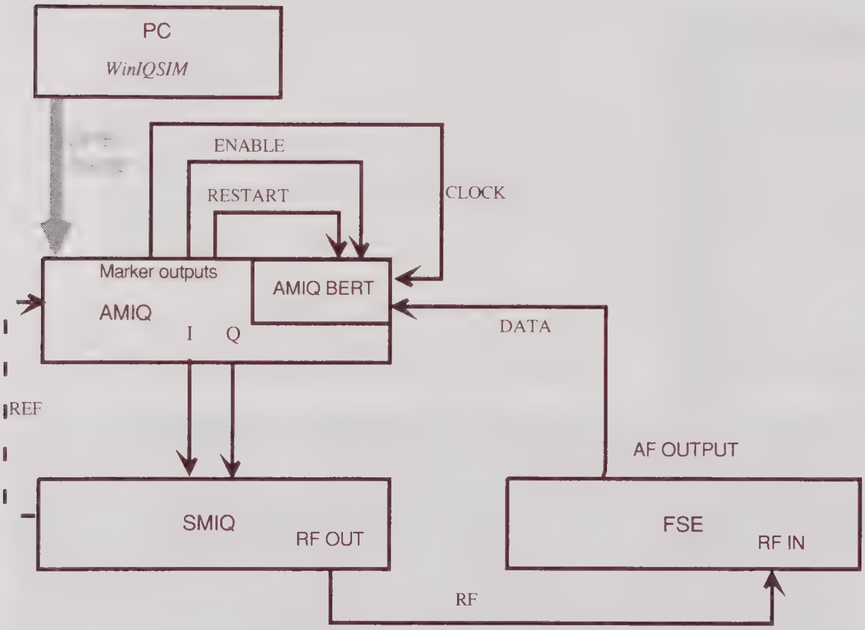


Fig. 5-12: Test setup for BER measurement demonstration using FSE spectrum analyzer as device under test.

The FSE (with option FSE-B7) is used as the online FSK demodulator (setting: analog demodulation, FM signal, DC coupling, real time on). The AF output signal of the FSE available on the front panel is connected by means of a jack plug (stereo 3.5 mm)[21] to the data input of the AMIQ. The other connections (clock, enable, restart) are as in the stand-alone demo setup.

Creating the data sources

We can reuse the data sources from the stand-alone demo setup, adapting the modulation settings to the new scenario and reprogramming the markers.

Open the settings file BER_SELF_TEST.IQS and save it as BER_TEST.IQS. (This is to keep the stand-alone demo settings for later use.) Change the modulation settings in BER_TEST.IQS as shown in Fig. 5-13. As the control signals **clock**, **enable** and **restart** depend on the modulation used, we have to program the markers again. Load the data editor settings file BER_SELF_TEST.DED and save it as

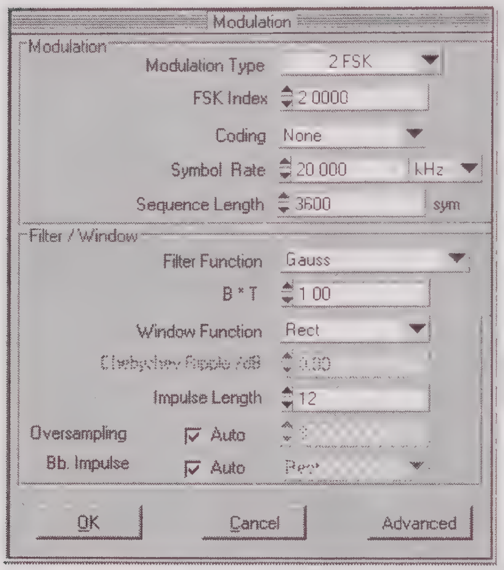
---

[21] For this you need again the appropriate AMIQ-B1 cable and an adaptor with the jack plug (stereo 3.5 mm, both center connectors tied together) on one side and a BNC connector on the other.

BER_TEST.DED. Change the name of the sequence to be calculated to BER_TEST.DBI, then activate „**calculate and save sequence**". Save the data editor settings (BER_TEST.DED) again.

To keep these settings, save BER_TEST.IQS again, then calculate the waveform and transmit it to the AMIQ harddisk as file BER_TEST.

Now we produce a second waveform containing some errors. With the settings BER_TEST.IQS, open the `data source` panel and change the data source **file** from BER_TEST.DBI to BER_ERR.DBI. *Don't change anything else* and calculate the waveform. As we designed all data sequences with the same structure and length, the marker settings need not be changed. Save the waveform on AMIQ harddisk as BER_ERR.



Modulation Type: 2 FSK
FSK Index: 2.0000
Coding: None
Symbol Rate: 20.000 kHz
Sequence Length: 3600 sym
Filter Function: Gauss
B * T: 1.00
Window Function: Rect
Chebyshev Ripple /dB: 0.00
Impulse Length: 12
Oversampling ☑ Auto
Bb. Impulse ☑ Auto Rect

Fig. 5-13: Modulation settings for the BER test demo with FSE

Measuring the delay in the signal path

In this setup there is a significant delay in the RF signal path with respect to the control signals. For correct BER tester performance this delay has to be measured using the MARK slot created above. Open the data editor again (BER_TEST.DED) and create a frame with one MARK slot and 19 dummy slots. Save this sequence as BER_DELAY.DBI, the data editor settings as BER_DELAY.DED and the WinIQSIM settings as BER_DELAY.IQS. Calculate the waveform and transmit it ito the AMIQ RAM and harddisk. This is a signal containing **zeroes**, except for a single **one**. At the position of this **one**, there is a trigger signal with length one symbol on marker 4. Connect the signal from FSE AF output and the AMIQ marker 4 output to a 2-channel oscilloscope.

Open the `AMIQ --> remote control and BERT...` panel and shift marker 4 with respect to the signal output so that the data bit **one** and the marker 4 signal appear at the oscilloscope at the same time.

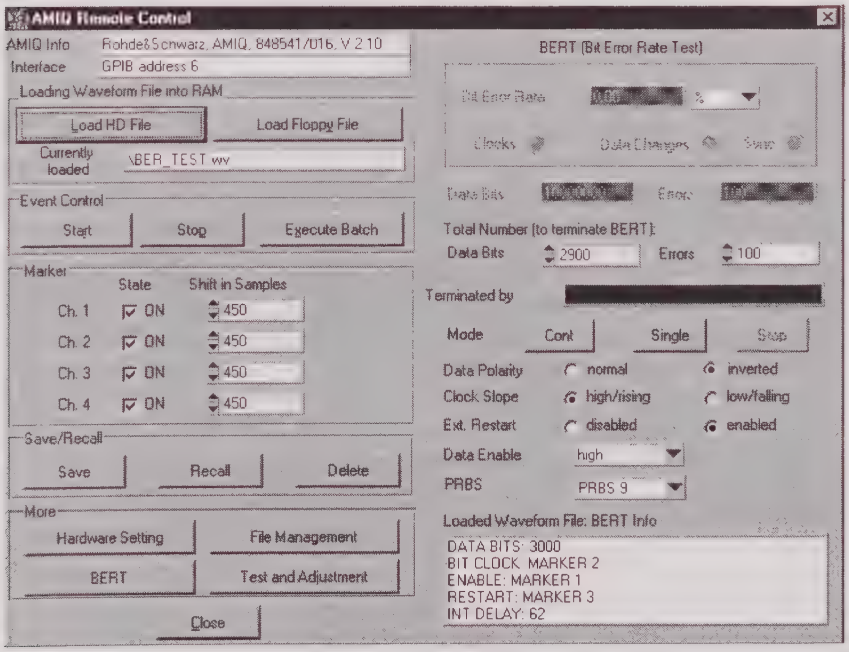
The value of the marker shift depends on the units in the signal path and the cable lengths. For this setup it will probably be in the range of 450 samples (about 2.5 ms). Set all marker shifts to the measured value.

Measuring the bit error rate

Now connect the FSE AF output to the AMIQ BER tester data input again and set SMIQ and FSE as shown in the table below.

SMIQ:	PRESET	
	FREQ	1 GHz
	LEVEL	0.0 dBm
	VECTOR MOD:	STATE ON
FSE:	PRESET	
	CENTER	1GHz
	LEVEL REF	0 dBm
	MODE:	VECTOR ANALYZER: ANALOG DEMOD
	MEAS RESULT: FM SIGNAL:	REAL TIME ON
	VOLUME:	80%
	MODULATION PARAMETER:	AF COUPL'G DC
	RANGE:	Y PER DIV: 10 kHz
	SWEEP:	SWEEP TIME 1 ms

Load the waveform BER_TEST into AMIQ RAM and open the `BERT` panel (menu `AMIQ --> remote control and BERT --> BERT`). Set the BERT parameters as shown below, with the marker shift value you measured. **Data polarity** must be **inverted**.



AMIQ Info: Rohde&Scnwarz, AMIQ, 848541/016, V 2.10
Interface: GPIB address 6
Currently loaded: \BER_TEST.wv

Ch. 1 ☑ ON 450
Ch. 2 ☑ ON 450
Ch. 3 ☑ ON 450
Ch. 4 ☑ ON 450

Total Number (to terminate BERT):
Data Bits: 2900
Errors: 100
Data Polarity: ○ normal ● inverted
Clock Slope: ● high/rising ○ low/falling
Ext. Restart: ○ disabled ● enabled
Data Enable: high
PRBS: PRBS 9

Loaded Waveform File: BERT Info
DATA BITS: 3000
BIT CLOCK: MARKER 2
ENABLE: MARKER 1
RESTART: MARKER 3
INT DELAY: 62

Fig. 5-14: AMIQ BER test parameters for the test setup with FSE

Start the BER measurement with **single**. If everything was set correctly the BER tester should work, indicated by the green lights at the top of the panel, and show an error rate of zero.

If the BER tester does not count, check the cabling and the marker outputs (maybe they are switched off).

If an error of about 50% occurs, check the data polarity, the PRBS type (PRBS 9) and the marker delay. Sometimes the clock signal is shifted half a symbol with respect to the data signal, which may cause faulty triggering. Try shifting the clock by one or two samples.

If the error indicator reads a small but nonzero error, the markers are not positioned exactly and the BER tester counts one bit of the header or guard of the sequence. Shift the enable and restart markers in multiples of 9 samples (= 1 symbol) forward or backward until BER reads zero errors.

Bit errors can be introduced by decreasing the SMIQ output level significantly. You can also try the same test with the waveform BER_ERR. This should result in 2 errors per single measurement (at 0.0 dBm SMIQ level).

6 Special applications

6.1 Creating a sinewave signal

The AMIQ / WinIQSIM combination was designed for applications in digital communication systems. It is not recommended for use as a conventional function generator. However, there are situations sometimes where one needs a simple periodic signal, e.g. for test purposes. It is possible to create such basic signals with WinIQSIM by applying some little tricks. (All this is done in single carrier system.)

First of all, a *periodic rectangular signal* is easy to create [22]. Use **BPSK** or **QPSK** modulation with baseband **filter function rect** (**baseband impulse Dirac**, **window rect**) and specific patterns as **data source** as listed below.

BPSK, **pattern** 10, **symbol rate** 1 MHz (**Oversampling** 32)
--> rectangular signal with frequency 500 kHz on I output.

QPSK, **pattern** 1011, **symbol rate** 1 MHz (**Oversampling** 32)
--> rectangular signal with frequency 500 kHz on I output

QPSK, **pattern** 1001, **symbol rate** 1 MHz (**Oversampling** 32)
--> rectangular signals with frequency 500 kHz on I and Q outputs, in phase.

QPSK, **pattern** 00011011, **symbol rate** 1 MHz (**Oversampling** 32)
--> rectangular signals with frequency 250 kHz on I and Q outputs, opposite phases.

It is also possible to create *sinewaves*. In this case use **CW** as **modulation type** with a baseband **filter function rect** (**baseband impulse Dirac**, **window rect**). Choose symbol rate and oversampling so that the resulting sample rate is much bigger than the desired frequency of the sinewave. Then put a frequency offset on the signal. The offset frequency gives the frequency of the sinewave [23].

To explain: suppose a sinewave of 1 MHz is to be created. Open the `single carrier` system and then the `modulation settings` panel. Set the parameters as seen in Fig. 6-1. The sample rate is then 40 MHz which gives very good resolution without stressing the DAC due to extremely high clock rates. Open the `offset` panel and set the **frequency offset** to 1 MHz using the **assistant** function. The relative phase of the sinewave can be adjusted with the **phase offset** function in the `offset` panel. The phase of the offset oscillation depends on the modulation settings, if one needs a defined starting phase (e.g. for triggered signals) one must adjust the phase individually for each setup.

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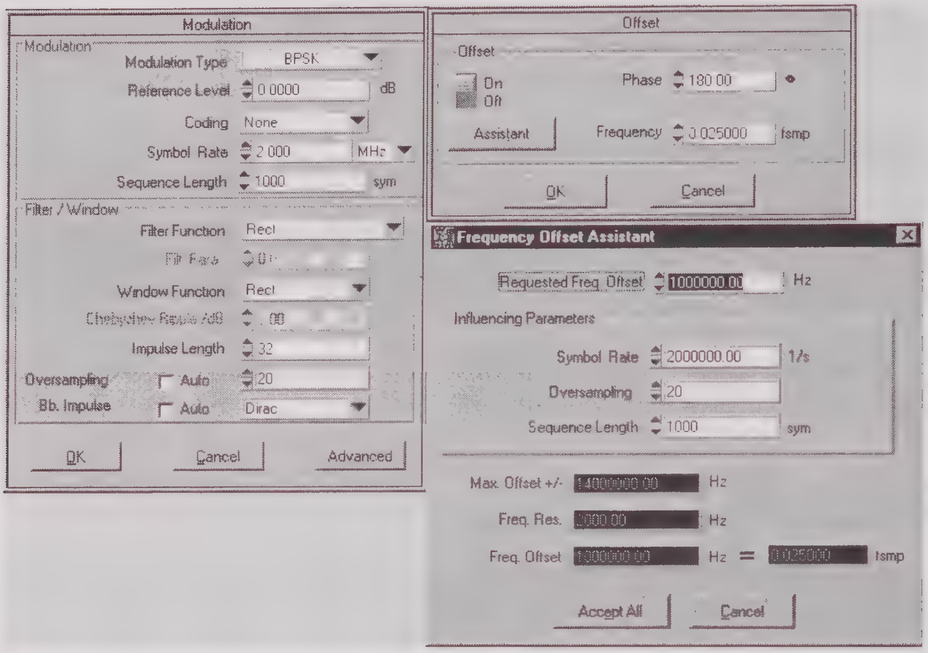
[22] With the restriction that the correction due to hardware properties may result in some overshootings at the step points, see chapter 2. To avoid overshootings, use your own ASCII files and AMIQ-K2.

[23] A closer look at sections 4.1 and 4.2 will provide the theoretical background of this method.

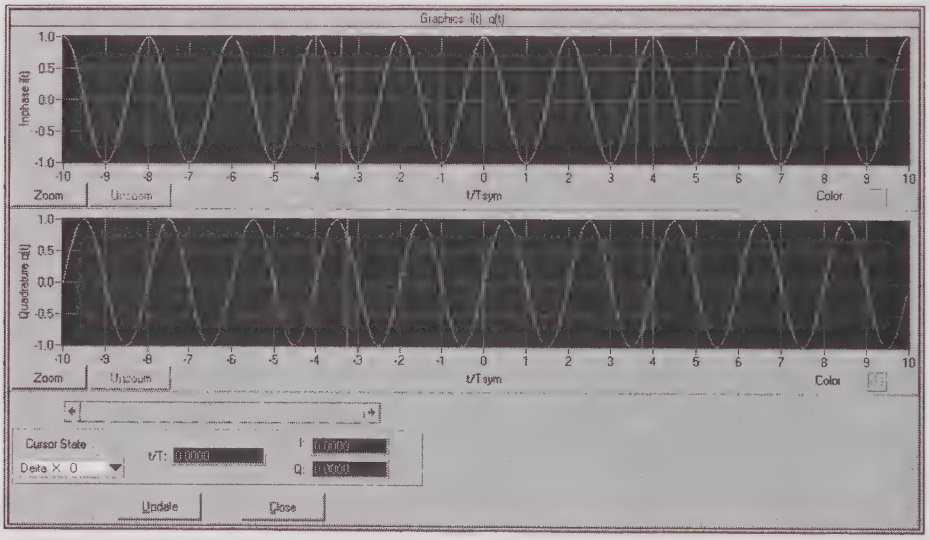


Modulation Type: BPSK
Reference Level: 0.0000 dB
Coding: None
Symbol Rate: 2.000 MHz
Sequence Length: 1000 sym
Filter Function: Rect
Window Function: Rect
Impulse Length: 32
Oversampling ☐ Auto: 20
Bb. Impulse ☐ Auto: Dirac

On / Off
Phase: 180.00 °
Frequency: 0.025000 fsmp

Requested Freq. Offset: 1000000.00 Hz
Symbol Rate: 2000000.00 1/s
Oversampling: 20
Sequence Length: 1000 sym
Max. Offset +/-: 14000000.00 Hz
Freq. Res.: 2000.00 Hz
Freq. Offset: 1000000.00 Hz = 0.025000 fsmp

Fig. 6-1: *Modulation settings and frequency offset for creating sinewave signals. With these settings the phase offset of 180° produces a cosine (value 1 at T=0) on I output and a sine (value 0 at T=0) on Q output.*



Delta X 0
t/T: 0.0000
I: 0.0000
Q: 0.0000

Fig. 6-2: *Calculated I and Q signals with the settings from fig 6-1.*

It is also possible to use the `multi carrier` system for this application (create two CW carriers). Furthermore one may use a **MSK** modulation with **data source „all one**“ or „**all zero**“.

If the desired frequency is in a higher range (for example 5-10 MHz) the oversampling with respect to the period of the sinewave is too small to produce good results. For a 10 MHz signal there are at most 10 sampling points per period and that is not enough, and results in a step function that approximates the sine or cosine. This signal can also be described as a sum of the desired sinewave and its harmonics. To get a good analog sine signal, suppress the harmonics with an appropriate hardware lowpass filter.

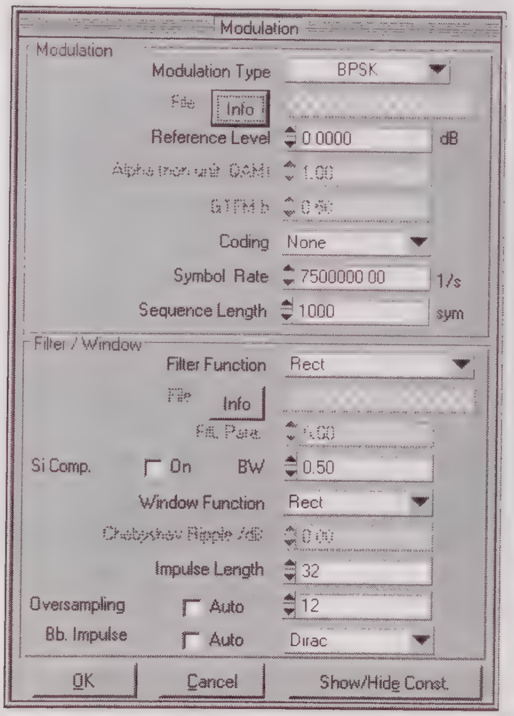
6.2 Creating noise without carriers

Creating a noise without any useful signal may be a little excentric at the first look. However there are some applications where Gaussian noise is used for amplifier testing. As WinIQSIM is not designed for creating no signals one has to act trickily again.

The procedure is to create a simple signal, add noise and then compensate the signal by adding an identical carrier with opposite phase.

To demonstrate this, we will create a white gaussian noise with 30 MHz bandwidth.

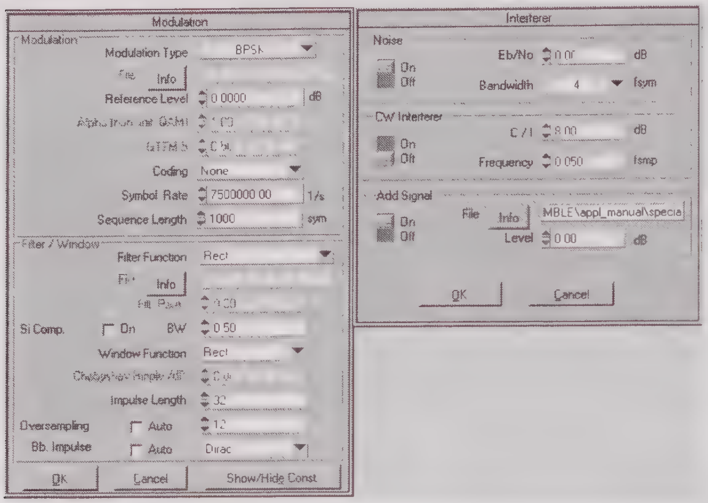
First we create the additional signal for compensation. Open a new `single carrier` setting and choose **BPSK** modulation with **data source all zero**. The `modulation settings` should be as shown in Fig. 6-3.



Modulation Type: BPSK
Reference Level: 0.0000 dB
Alpha (mod. QAM): 1.00
GTFM b: 0.50
Coding: None
Symbol Rate: 7500000.00 1/s
Sequence Length: 1000 sym
Filter Function: Rect
Filt. Para.: [illegible]
Si Comp. ☐ On BW: 0.50
Window Function: Rect
Chebyshev Ripple /dB: 0.00
Impulse Length: 32
Oversampling ☐ Auto 12
Bb. Impulse ☐ Auto Dirac

Fig. 6-3: Modulation settings for a BPSK all zero signal.

Calculate the signal and **save** it **for add** as BPSK_ALLZERO.IBN. Now create the noise as follows. Change the **data source** to **all one** and leave all **modulation settings** unchanged. Open the `interferer` panel and turn on the **noise** function. Set the bandwidth to four times the symbol rate which gives 30 MHz. E_b/N_0 should be 0 dB. Activate the `add signal` function and select BPSK_ALLZERO.IBN as file. The relative power has to be 0 dB (see Fig. 6-4). Then the **BPSK all zero** and **all one** signals cancel each other and the pure noise part is left.



Modulation Type: BPSK
Reference Level: 0.0000 dB
Coding: None
Symbol Rate: 7500000.00 1/s
Sequence Length: 1000 sym
Filter Function: Rect
Si Comp. ☐ On BW 0.50
Window Function: Rect
Impulse Length: 32
Oversampling ☐ Auto 12
Bb. Impulse ☐ Auto Dirac

Noise: On / Off (Off)
Eb/No: 0.00 dB
Bandwidth: 4 fsym
CW Interferer: On / Off (On)
C / I: 8.00 dB
Frequency: 0.050 fsmp
Add Signal: On / Off (Off)
File: MBLE\appl_manual\specia
Level: 0.00 dB

Fig. 6-4: *Modulation settings, noise and add signal for the „pure noise signal“.*

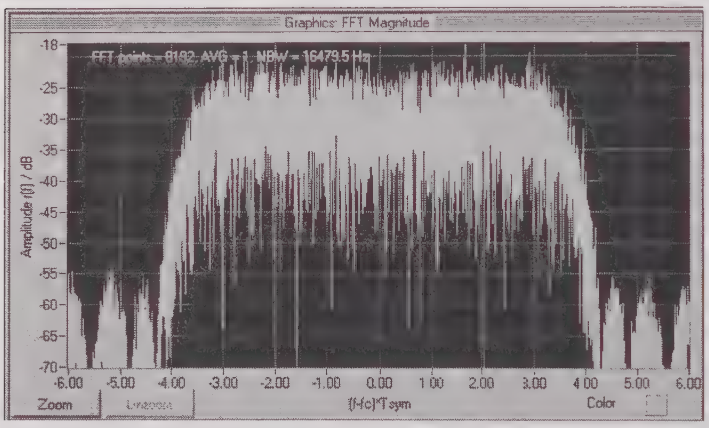


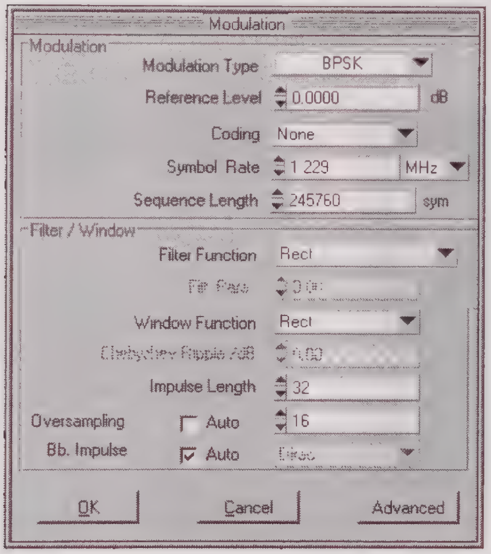
Fig. 6-5: *FFT magnitude spectrum of the „pure noise signal“.*

6.3 Noise signals with filter shaping

A more ambitious application is to shape the noise signal with a filter function. Such signals are sometimes used for amplifier tests. This is an opportunity to use the `receiver filter` function in WinIQSIM. As the `receiver filter` follows the `noise` generation in the signal path, the noise signal can be shaped with the filter.

In the examples folder provided with WinIQSIM there are several baseband filters normally used for IS-95 applications. We will take one of them for designing a receiver filter. Take a look at the EXAMPLES\IS-95 folder in your WinIQSIM folder. Use the Windows Explorer or a similar tool to copy the filter file CDMA_BS.IFL and to change the name of the copy into CDMA_BS.IRF. As the baseband and receiver filter file format is the same, this is the easiest way to get a receiver filter.

Recalculate the BPSK all zero signal with the following modulation settings:



Modulation Type: BPSK
Reference Level: 0.0000 dB
Coding: None
Symbol Rate: 1 229 MHz
Sequence Length: 245760 sym
Filter Function: Rect
Window Function: Rect
Impulse Length: 32
Oversampling ☐ Auto 16
Bb. Impulse ☑ Auto

Fig. 6-6: Modulation settings for the BPSK all zero signal, used for the filtered noise signal.

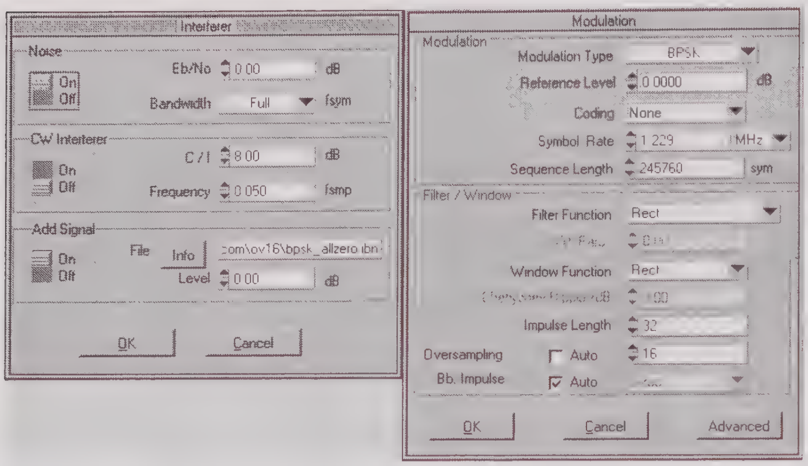
Now recall the noise setting from the last section and change the **bandwidth** of the **noise** signal (in the `interferer` menu) from **4** to **full**. This is necessary to approximate the correct CDF function for the gaussian noise - the ideal noise would have infinite bandwidth. The **sequence length** is also set to a much larger value. Complete the settings as shown in Fig. 6-7.

Open the `receiver filter` panel and choose CDMA_BS.IRF as file. The file was designed for Oversampling 16 and window length 32 [24], so the corresponding **modulation settings** are done in this way. Activate the **receiver filter** function, start calculation and take a coffee break, as calculation will take a while.

Calculation of the waveform should give a result as shown in Fig. 6-8. Such shaped noise signals are sometimes used in CDMA amplifier testing instead of real CDMA scenarios because the spectra are very similar. However, the CDF of a real CDMA signal differs significantly from a Gaussian noise CDF in most cases.

---

[24] This information is provided in the header of the filter file. See WinIQSIM user manual for further explanation.



Noise
○ On ● Off
Eb/No 0.00 dB
Bandwidth Full fsym

CW Interferer
● On ○ Off
C / I 8.00 dB
Frequency 0.050 fsmp

Add Signal
○ On ● Off
File ...om\ov16\bpsk_allzero.ibn
Level 0.00 dB

Modulation
Modulation Type BPSK
Reference Level 0.0000 dB
Coding None
Symbol Rate 1.229 MHz
Sequence Length 245760 sym

Filter / Window
Filter Function Rect
Window Function Rect
Impulse Length 32
Oversampling ☐ Auto 16
Bb. Impulse ☑ Auto

Fig. 6-7: Noise, add signal and modulation settings for the filtered noise signal.

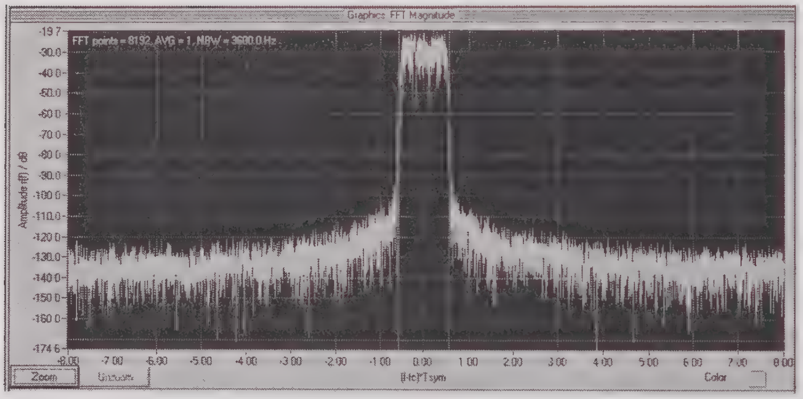


Fig. 6-8: FFT magnitude for the filtered noise signal.

7 References

I/Q Modulation Generator AMIQ, Operating Manual, Rohde & Schwarz, 1998

Software WinIQSIM for Calculating I/Q Signals for I/Q Modulation Generator AMIQ, Software Manual, Rohde & Schwarz, 1998

R. Minihold: *Demonstration of BER Test with AMIQ controlled by WinIQSIM*, Application Note 1MA16_0E, Rohde & Schwarz, 1998

R. Desquiotz: *Bit Error Rate Measurements with AMIQ and WinIQSIM*, Application Note 1GP36_0E, Rohde & Schwarz, 1999

W. Stößel, *Fourieroptik*, Springer Berlin, 1993

8 Utilities

Archive with example files

All the examples used in this manual are delivered with the WinIQSIM CD-ROM (WinIQSIM Version 3.0 or higher). The WinIQSIM setting files and the waveforms can be found in the folder \APPL_MAN\ARCHIVE. See the README in that folder document for details.

4 Communications or System-Theoretical Model of Transmission System

This chapter describes the communications or system-theoretical model of the transmission system used by WinIQSIM. An equivalent baseband model, ie a model simulating the effects of RF transmission in the baseband, is used for this purpose.

4.1 Model of Single-Carrier Transmission System

A simple block diagram of the single-carrier transmission system in the equivalent baseband is shown first and then extended.

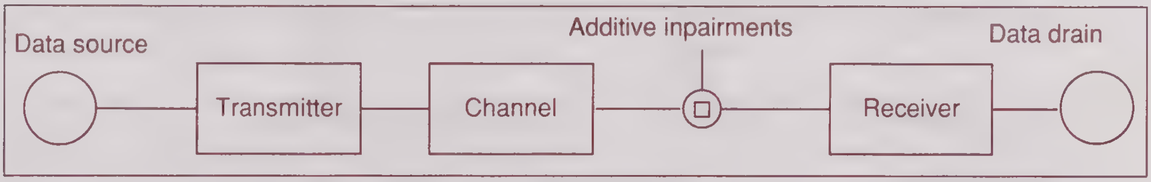


Fig. 4-1: Simple single-carrier transmission system

The data source generates a binary data stream which is forwarded to the transmitter. The transmitter assigns values to the binary input data at the complex level depending on the selected modulation. It also performs pulse shaping, baseband filtering, I/Q modulation and signal amplification. The signal is then transmitted to the receiver in the channel (eg via a satellite or cable link). To simulate the additive signal impairments normally occurring on the transmission path, an impairment signal is superimposed onto the signal before it arrives at the receiver input. The receiver demodulates the signal and may also use a matched filter. The receiver forwards the demodulated signal to the data drain.
With the aid of WinIQSIM, the whole transmission path to the receiver can be simulated. The receiver filter can also be simulated.

This model of a single-carrier transmission system is now refined (see Fig. Fig. 4-2 Advanced transmission system model).

The binary data stream from the source is at first applied to the coding block where n input bits are assigned to m output bits. This means that an input sequence of n bits is coded into an output sequence of m bits. This coding may be influenced by previous coding states (eg differential coding). The coding modes offered by WinIQSIM do not contain redundancies (ie m = n). They are used for reorganization and not for error detection or correction. *File* is available as a data source to simulate functions like channel coding or interleaving. A data stream that has already modified by channel coding and interleaving may also be used as a signal source (see sections Data Source in chapter 5).

The coding block is followed by the modulation mapping block. Here n input bits (n = modulation level, eg n = 3 with 8PSK) are displayed as a pair of Gaussian values. After modulation mapping, the real, binary input data stream becomes a complex, non-binary output data stream. The signal now consists of an in-phase or real component (I part) and a quadrature or imaginary component (Q part).

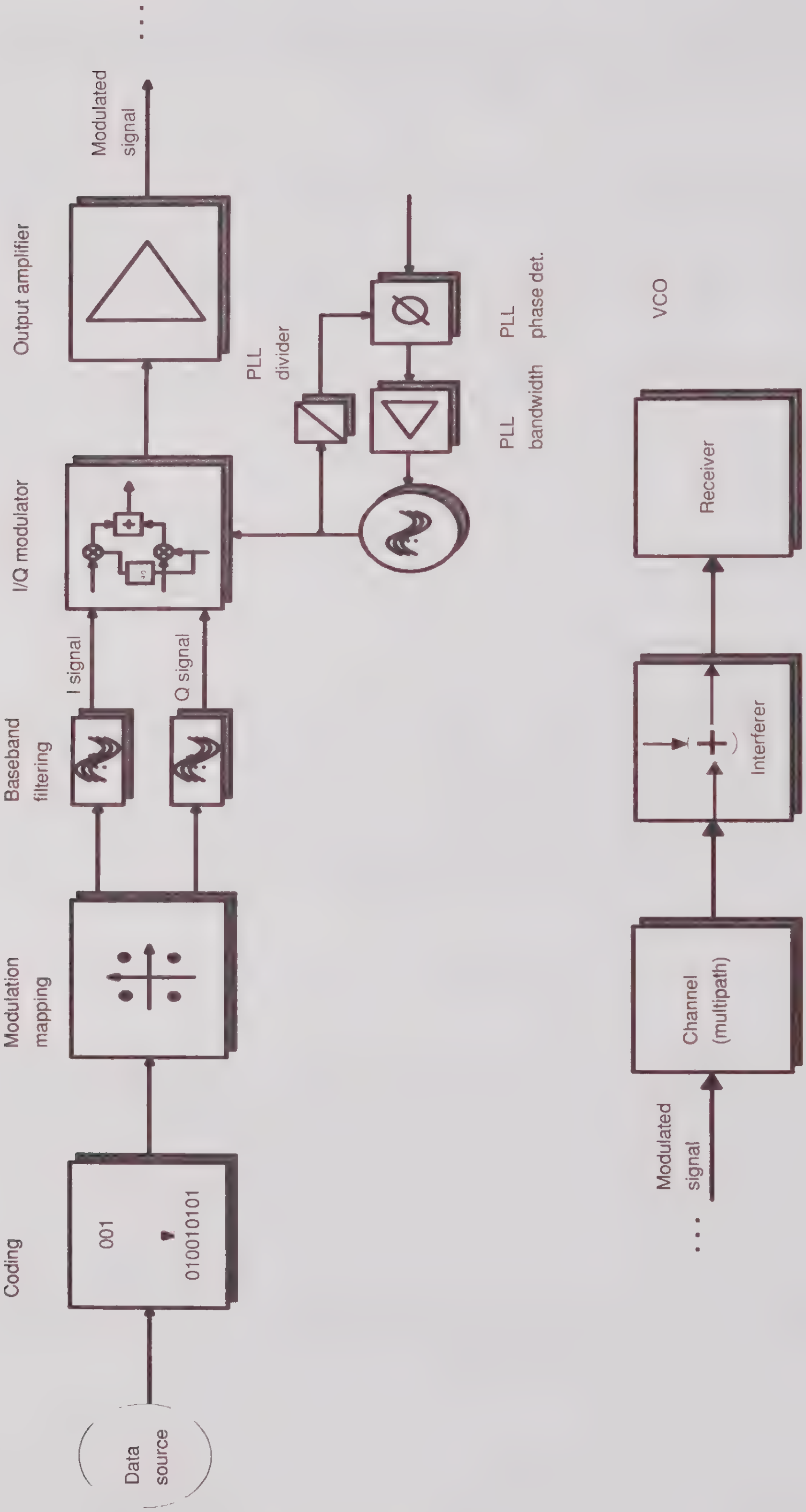


Fig. 4-2 Advanced transmission system model

This complex output signal is routed to the baseband filtering or pulse shaping block. This block is decisive for signal shaping in the time and frequency domain. The signal spectrum can be clipped and impairments like crosstalk reduced with the aid of a lowpass filter, eg a Gaussian filter, and a suitable window function. The real and imaginary part of the modulation mapping output signal are interleaved in WinIQSIM by the same combination of a (real) bandpass filter and a (real) window function.

After baseband filtering, the signal is applied to the I/Q modulator where the complex signal is modulated onto a carrier. The I component is multiplied by a carrier signal and the Q component by the carrier signal shifted by 90°. The two results are then added. The carrier signal is generated by an oscillator (VCO) operating in a phase-locked loop (PLL).

The modulated carrier signal is applied to the output amplifier. The amplified signal is transmitted in the channel (eg a mobile radio link) to the receiver. Initially an ideal channel without signal distortions (in the model implemented by the response characteristic $H(f) = 1$ or $h(t) = \delta(t)$) is assumed.

To simulate the additive signal impairments normally occurring on the transmission path, an impairment signal is superimposed onto the signal before it arrives at the receiver input. A more detailed description will be given below.

To optimize the S/N ratio, matched filters are often used in the receivers. The impulse response of these filters corresponds to that of the baseband filter in the transmitter (for an ideal channel and a real, symmetrical pulse). Assuming linear demodulation in the receiver, matched filtering can be performed before the signal is demodulated. The channel is therefore first applied to the receiver filter block in the transmission model.

Up to this point (and with ideal transmission), the signal flow can be simulated by WinIQSIM. However, since only one simulation is performed in the equivalent baseband for calculating the I and Q signals, I/Q modulation is not performed. This is done later in the Vector Signal Generator SMIQ from Rohde & Schwarz. The I/Q modulator is only contained in the block diagram to illustrate the principle.

Up to now an ideal transmission system has been assumed. In practice this is hardly ever the case. For this reason a large part of the WinIQSIM functions is concerned with the simulation of impairment signals as are produced by almost all components of the transmission model. This function will be dealt with in the following section.

Interference simulation with WinIQSIM

As already mentioned, WinIQSIM does not simulate I/Q modulation, but the impairments that may be caused by a real I/Q modulator are taken into account. Thus I/Q imbalance, carrier leakage and quadrature errors can be simulated for instance. It is also possible to simulate VCO noise or phase and frequency offsets as are produced by the oscillator in carrier generation.

In many communications systems the baseband signal is converted into one (or in steps to several) intermediate frequencies (IF) before conversion to the RF. The effect of the filters used at the IF can be eliminated by means of a configurable bandpass filter in the signal path.
Nonlinearities of the output amplifier like AM/AM conversion or clipping due to overdriving are also considered.

Modern radiocommunication systems often use RF power ramping, ie the RF signal is switched off or the power is considerably reduced when no information is transmitted. This function can also be simulated.

Electromagnetic radio waves are propagated in different directions. The waves can be reflected, refracted or scattered. As a result they arrive at the receiver on different paths and with different delays. In mobile radio communication this effect depends on the nature of the terrain, ie in mountain areas more reflected waves arrive at the receiver than in a flat area without buildings. This multipath propagation can also be simulated by WinIQSIM.

Additive, superimposed interfering signals may occur in addition to the above-mentioned impairments. They include noise (eg thermal noise), adjacent-channel interference and CW interferers. These effects are also considered.

In modern communications systems, digital components like signal processors are used to an increasing extent. These components have a limited computing accuracy as the number of bits available for resolution is limited. For this reason the resolution of filter coefficients and I/Q signals can be set in WinIQSIM.

5 User Interface

This chapter gives a detailed description of the WinIQSIM user interface. First the main panel of WinIQSIM is described, which is the operating and control interface for the whole program. From here all program functions are accessible. This panel is displayed after the start of WinIQSIM. The program always loads the previously used settings so that operation can be easily continued. Most of the setting panels displayed on this workspace can be arranged next to each other as required. Thus a user-specific interface can be created. The panel is subdivided into frequently needed parameters on the left side and special, less frequency needed parameters on the right side. In the default setting only the left part of the panel is displayed. With the **Advanced** button the panel can be expanded for display of the special parameters.

Note: *Irrespective of the Advanced section of the panel being displayed or not, the parameters set there are effective.*

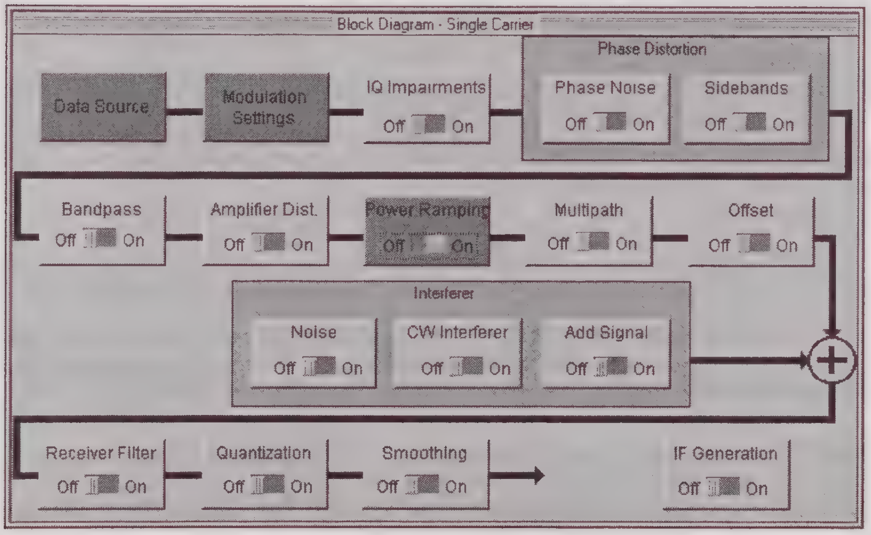


Fig. 5-1 Main panel as workspace (single carrier)

The program name WinIQSIM and the currently used system in brackets are displayed in the headline of the main panel. The name of the currently loaded configuration file follows after a dash.

There is only a slight difference between the main panels of the single-carrier, multicarrier,3 GPP W-CDMA and IS-95 systems.

The operating menu with toolbar, the status line, the block diagram and all the other control windows of WinIQSIM are described first.

5.1 Main Panel Operating Menu

Tabulated overview of operating menu:

Table 5-1 Overview of main panel operating menu

File	System	Data	Modulation	Impairments	Graphics	AMIQ	Window	Help
• New • Open • Save As • Save for Add • Show Report • Exit		• Data Source • Data Editor	• Mod. Settings (with Single and Multi Carrier), or 3 GPP W-CDMA Filtering or IS-95 Filtering • 3 GPP W-CDMA Configuration • IS-95 Configuration • Carrier Settings • Power Ramping • Receiver Filter • IF Signal Generation	• IQ Impairments • Phase Distortion • Bandpass • Amplifier Distortion • Multipath • Offset • Interferer • Quantization • Smoothing	• Settings • Show Graphic • Print	• Transmission • Show Signal Statistics and Quantizsation • Remote Control • Marker Setting • BERT	• Tile Windows • Cascade Windows • List of active Windows	• Contents • Search • • • About

This overview is followed by a brief description of individual menu functions. The main functions are also accessible via the toolbar below the menu selection line (see section 5.2). In the following list, the toolbar icons for the various functions are shown at the left of the menu item.

File		
	New	Calls up the single-carrier, multicarrier, 3 GPP W-CDMA or IS-95 system with factory settings of Rohde&Schwarz.
	Open	Loads a previously stored configuration file containing all WinIQSIM settings.
	Save As	Stores all settings made by WinIQSIM in a configuration file.
	Save for Add	Stores the I and Q signals with an internal format for subsequent use with the Add Signal function.
	Show Report	Prepares a one-page report containing main signal parameters and the current graph for documentation.
	Exit	Quits WinIQSIM with the option to store the current settings.
System		Switches to another system, single carrier, multicarrier, 3 GPP W-CDMA or IS-95, with the previous settings of the system.
Data		
	Data Source	Opens the Data Source panel where a data source (eg bit pattern or PRBS) can be selected.
	Data Editor	Calls the data editor, which is a convenient tool for generating data files in line with TDMA standards. In addition to the graphics display of data structures, the editor allows power ramping to be defined at the data level.

Modulation

Modulation Settings	This item is only accessible in the single-carrier and multicarrier modes. It opens the Modulation Settings panel where the main parameters like type of modulation, coding, symbol rate, filter and window function as well as oversampling can be set.
3 GPP W-CDMA Filtering	Here the parameters of baseband filtering for 3 GPP W-CDMA signals are set..
IS-95 Filtering	Here the parameters of baseband filtering for IS-95 signals are set.
3 GPP W-CDMA Configuration	This item is only accessible in the 3 GPP W-CDMA mode. It opens the 3 GPP W-CDMA configuration panel where the main 3 GPP W-CDMA signal parameters are set.
IS-95Configuration	This menu item is only accessible in the IS-95 mode. It opens the IS-95 Configuration Panel, where the main parameters of a IS-95 signal are set.
Carrier Settings	This item is only accessible in the multicarrier mode. It opens the Carrier Settings panel where the main parameters of a multicarrier signal, the number of carriers, carrier spacing, modulation and carrier power are set.
Power Ramping	Opens the Power Ramping panel where a power profile can be defined at the modulation symbol level. This profile is used for weighting the calculated I/Q signals.
Receiver Filter	Opens the Receiver Filter panel. A receiver filter switched into the signal path, eg for evaluating the matched filter characteristic, can be selected.
IF Signal Generation	Calls the IF Signal Generation panel where an IF can be set. The two-channel I/Q signal is then computed into a single-channel IF signal.

Impairments

With the items of the Impairments menu, the undisturbed I/Q signal can be exposed to a number of interferences. When an item is selected, a panel of identical name is opened. The settable impairments are briefly described below.

IQ Impairments	Faults of the I/Q modulator like carrier leakage, quadrature error or I/Q Imbalance, can be defined in this panel.
Phase Distortion	This option allows the simulation of impairments caused by carrier phase noise and spurious sidebands.
Bandpass	Under this item the effects of an RF bandpass filter, eg an IF filter, can be simulated.
Amplifier Distortion	Provides functions for simulating nonlinear effects caused by the amplifier eg AM/AM conversion or clipping due to overdriving.
Multipath	In this panel, the effects of multipath propagation on up to 6 signal paths can be simulated.
Offset	In this panel a constant phase offset or a constant frequency offset can be added to the I/Q signal.
Interferer	With the functions of this panel, three kinds of additive impairment signals can be superimposed on the I/Q signal: a noise signal, a CW interferer with adjustable amplitude and another I/Q signal (eg from an adjacent channel).
Quantization	Here the effects caused by the limited resolution of digital components in signal processing can be simulated. The resolution of the I/Q signals and of the coefficients of the employed filters can be varied.
Smoothing	In many cases, an I/Q source or a loaded I/Q sequence is continuously output. Amplitude variations may occur at the so-called wrap around point between the end of a sequence and the beginning of the next. In this panel these irregularities can be smoothed.

Graphics

Settings	Determines the format for displaying the computed signal. The signal can be displayed in the formats i(t) and q(t), as a vector diagram or signal spectrum. The scale of the displays can also be selected.
Show Graphic	Triggers graphics display of the signal in the selected format. A zoom function and several cursors for the accurate read of signal values are integrated in

	the Graphics panel.
Print	Triggers a printout of the current graph with selectable colours for the traces and the background.
AMIQ	
Transmission	This panel controls transmission of the computed I/Q signals to AMIQ or to a file.
Show Signal Statistics and Quantization	This panel shows statistical values like average level or average and peak power of the I/Q signal. Taking these values as a basis, the user can define the range to be used for the quantisation of I/Q values of WinIQSIM to the 14-bit format of AMIQ.
Lowpass Filter	The I/Q signal is conditioned for a lowpass filter for the elimination of aliasing spectra.
Remote Control and BERT	From this panel the AMIQ can be remote-controlled. Remote control may be via IEC/IEEE bus or a serial interface. With the aid of this window or the subwindows called in the Remote Control panel, signal shapes can be output with AMIQ for instance, the AMIQ hardware configured and the signal waveforms on the AMIQ hard disk administered. Moreover, option AMIQ-B1 (Bit Error Rate Measurement) can also be controlled from this panel.
Marker Setting	AMIQ is provided with four marker channels which can be output in parallel with the I/Q data. In the Marker Setting panel the marker positions of all four marker channels can be defined at the sampling level.
Interface Option	Here parameters concerning the IEC/IEEE-bus or RS-232 interface to AMIQ can be set.
Window	
Tile Windows	All active windows of the main panel are arranged next to each other.
Cascade Windows	The active windows of the main panel are cascaded.
List of active windows/panel	After the menu item Cascade Windows a list of the active windows is displayed. Any window can be displayed in the foreground when the respective item is selected in the list.
Help	
Contents	The online help of WinIQSIM is selected with the aid of this list.
Search	The keywords for a search through the online help are displayed. With the aid of these keywords the relevant pages can be found.
About	A window with information on WinIQSIM, eg the version number, is displayed.

5.2 Toolbar of Main Panel

The main menu items can also be called in the toolbar below the menu selection line. When the mouse cursor is positioned on an icon, a short note on the selected icon is displayed. The function of the individual icons and the corresponding menu items can be seen below.

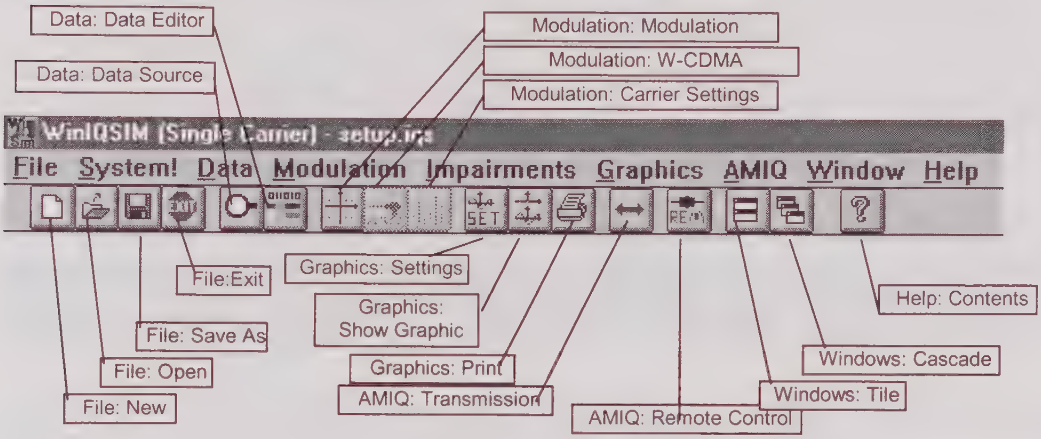


Fig. 5-2 Toolbar of main panel

5.3 Status Line

The main parameters of a transmission system are displayed in a status line below the toolbar of the main panel. So the set parameters can be seen at a glance.

The status line contains symbols for the different parameters; below the symbols the current parameter value is indicated. The drawing below shows the status line of the single-carrier system. The parameters pertaining to the symbols are also shown in the diagrams.

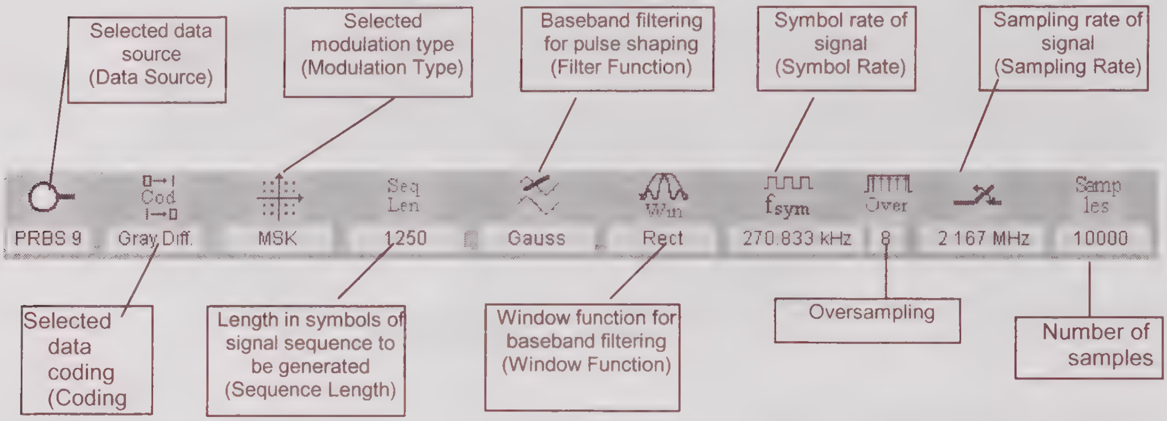

Selected data source (Data Source)
Selected modulation type (Modulation Type)
Baseband filtering for pulse shaping (Filter Function)
Symbol rate of signal (Symbol Rate)
Sampling rate of signal (Sampling Rate)
Cod
Seq Len
Win
fsym
Over
Samp les
PRBS 9
Gray Diff.
MSK
1250
Gauss
Rect
270.833 kHz
8
2.167 MHz
10000
Selected data coding (Coding
Length in symbols of signal sequence to be generated (Sequence Length)
Window function for baseband filtering (Window Function)
Oversampling
Number of samples

Fig. 5-3 Single-carrier status line

5.4 General on Operating Concept

Before describing the block diagram and all the other operating windows, some basic information shall be given on the operation of WinIQSIM.

The main or system panel serves as a workspace (user interface). All other panels are child panels of this window. They can be arranged on the main panel as required.

Most of the operating and setting windows are not modal windows (when a modal window is open, other panels of the program cannot be accessed until the open window is closed). In other words, in the case of non-modal windows several setting panels can be displayed next to each other and settings made alternately. All settings made in non-modal windows are immediately executed and need not be confirmed with OK or aborted with Cancel. The respective window may remain open.

These features make it possible to create a user-specific interface by calling up and arranging the panels that are relevant for a specific application. Thus all important parameters can be viewed and the user is not disturbed by irrelevant information.
To avoid the need to define a new configuration of these user-specific workspaces each time they are required, the position of the individual windows, their size and a list of the windows are automatically stored in a configuration file.

When WinIQSIM is started, the operating status of the last session is restored. All windows and settings required for defining an I/Q signal are reinstated.
However, the complete program setup (including panel positions) can also be stored by the user with the aid of menu item File:Save As (see section 5.1).

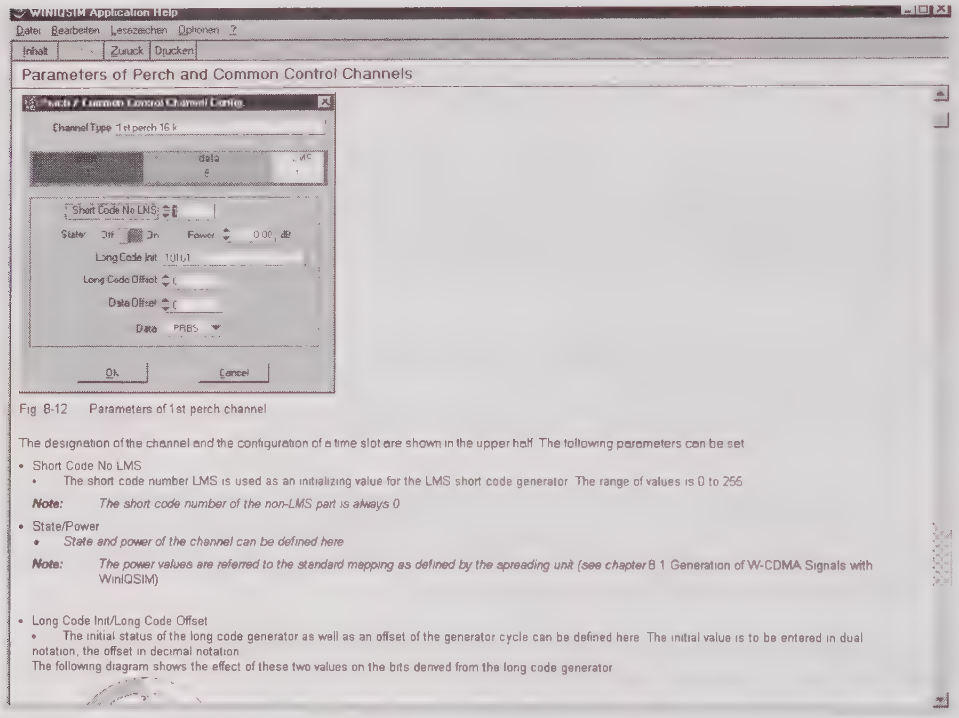
An **OK** button and a **Cancel** button are provided at the lower edge of each panel. Pressing the OK button closes the panel. Since all settings made in this panel are immediately executed, no other actions are required. Pressing the Cancel button also closes the panel but all settings made since the panel was called are rejected. The status of the panel before the call is restored.

The **shortcut Esc** may be used instead of the Cancel button in all panels. Pressing the Esc key in the active panel has the same effect as pressing the Cancel button.

The active panel is highlighted by a blue frame. Non-active panels are displayed with a grey frame. Only one panel at a time can be active.

5.4.1 Online Help

WinIQSIM is supplied with a context-sensitive online help function. This help function is available for 32-bit Windows only (Windows 95/ NT) and not for Windows 3.x. To obtain help with any panel simply click on this panel with the right mouse key. The online help will then automatically be called with the appropriate information.
An overview of the contents of online help can be reached via the menu **Help => Contents** or using the F1 key. A search for keywords within the help function is available via menu item **Help => Search**. The contents of the help function are to a large extent identical with those of the operating manual.



Parameters of Perch and Common Control Channels

Channel Type 1 st perch 16 k

Power 0.00 dB

Long Code Init 10101

Data PRBS

Fig 8-12 Parameters of 1st perch channel

The designation of the channel and the configuration of a time slot are shown in the upper half The following parameters can be set

- Short Code No LMS
  - The short code number LMS is used as an initializing value for the LMS short code generator The range of values is 0 to 255

Note: *The short code number of the non-LMS part is always 0*

- State/Power
  - *State and power of the channel can be defined here*

Note: *The power values are referred to the standard mapping as defined by the spreading unit (see chapter* 8 1 Generation of W-CDMA Signals with WinIQSIM)

- Long Code Init/Long Code Offset
  - The initial status of the long code generator as well as an offset of the generator cycle can be defined here The initial value is to be entered in dual notation, the offset in decimal notation

The following diagram shows the effect of these two values on the bits derived from the long code generator

Fig. 5-4 Online help for Perch Configuration Panel 3 GPP W-CDMA

5.5 Block Diagram

The block diagram is an essential part of each main system panel. The diagram is a multifunction window that can be shifted as required in the main panel. Displayed in the diagram are the selected transmission model, the signal flow, simple program control and operation and a fast overview of active signal impairments. These functions will be described in detail in the following.

There are only slight differences between the block diagrams of the single-carrier, multicarrier and 3 GPP W-CDMA systems. Function and meaning of the block diagram for the program run is the same for all systems.

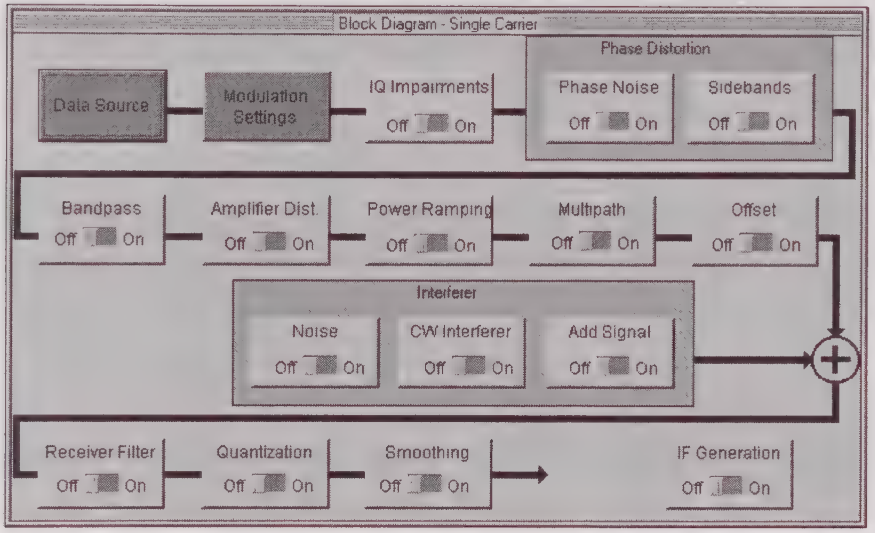


Fig. 5-5 Single-carrier block diagram

5.5.1 Display of Transmission Model and Signal Flow

Each section of the block diagram represents a functional component of signal generation. The block diagram therefore shows the transmission model used by WinIQSIM.

The first step in signal generation is the **Data Source.** Here the binary input data are defined. Only one data source is required for single-carrier transmission, several different data sources may be used for multicarrier, 3 GPP W-CDMA and IS-95 transmissions.

The data source is followed by the **Modulation Settings** block. Here the modulation parameters of the single-carrier signal like type of modulation, coding, baseband filter, symbol rate and oversampling are set. In the case of multicarrier signals, the modulation settings block is replaced by the **Carrier Settings** block. In addition to other parameters, the number and position of the carriers, the modulation to be used and the carrier power are defined by this block. With the 3 GPP W-CDMA system selected, the **3 GPP W-CDMA Configuration** block is displayed instead of the Modulation Settings block. The active coding channels with channel power and interleaved coding can also be defined in this block. With the IS-95 system, the **IS-95 Configuration** block appears at the second position in the diagram. Here the active code channels with their channel power, the useful data, the masks for the long codes and further parameters can be defined.

All other blocks are the same for all systems. They serve for simulating signal impairments and effects caused by the transmission channel and the receiver.

The **IQ Impairments** block is the first one to generate an interfering signal. It simulates impairments caused by the I/Q modulator such as carrier leakage or quadrature errors.

The IQ Impairments block is followed by two blocks that simulate **phase distortions.** The first of the two blocks (**Phase Noise**) generates phase noise, the other (**Sidebands**) spurious sidebands.

The next block (**Bandpass**) performs bandpass filtering. It allows the effects of IF filters to be reproduced for instance.
The bandpass block is followed by the **Amplifier Distortion** block. It simulates amplifier faults like AM/AM conversion or effects of overdriving.

In the **Power Ramping** block a performance profile can be created for the signal at the modulation symbol level. Thus a burst signal with defined ramps can be generated.
The **Multipath** block simulates multipath propagation, an effect frequently encountered in radio transmissions.

Constant frequency and phase offsets of the signal are generated in the **Offset** block.

The **Interferer** block simulates all additive interfering signals that occur along the transmission path. All these signals defined by the subblocks, ie noise (**Noise**), CW interferer (**CW Interferer**) and adjacent-channel signals (**Add Signal**), are added to the output signal of the Offset block.

The signal thus impaired is applied to the **Receiver Filter** block. This filter can be used as a matched filter for improving the S/N ratio.
The **Quantization** block simulates effects caused by the limited resolution of digital components in signal processing.

It is followed by the **Smoothing** block which smoothes the amplitude differences at the so-called wrap around point.

WinIQSIM also allows the conversion of the computed two-channel baseband I/Q signal into a single-channel signal at the IF. With the aid of this signal, generators provided with an IF input can be driven by the AMIQ. For a better overview, the **IF Generation** block required for this purpose is also part of the block diagram. This block is detached because it is only active when the signal is transmitted to AMIQ.

The block diagram illustrates the signal flow in the program. For internal signal calculation, the signal passes through all the blocks in the diagram in the given order. When a new signal is to be defined, the components of the transmission model should be configured in the order given in the diagram beginning with the data source.

5.5.2 Control and Operation of WinIQSIM via Block Diagram

The block diagram displays the transmission model and allows clear and simple operation of WinIQSIM. The block diagram is not a passive display window but an active control tool.

A click with the left mouse key on any block in the diagram opens the respective setting window. For instance, a click on the bandpass block opens the bandpass window where the bandpass filter can be configured. The currently configured block is highlighted by an orange frame for ease of identification. Thus the user always knows where actions are being made in the signal path.

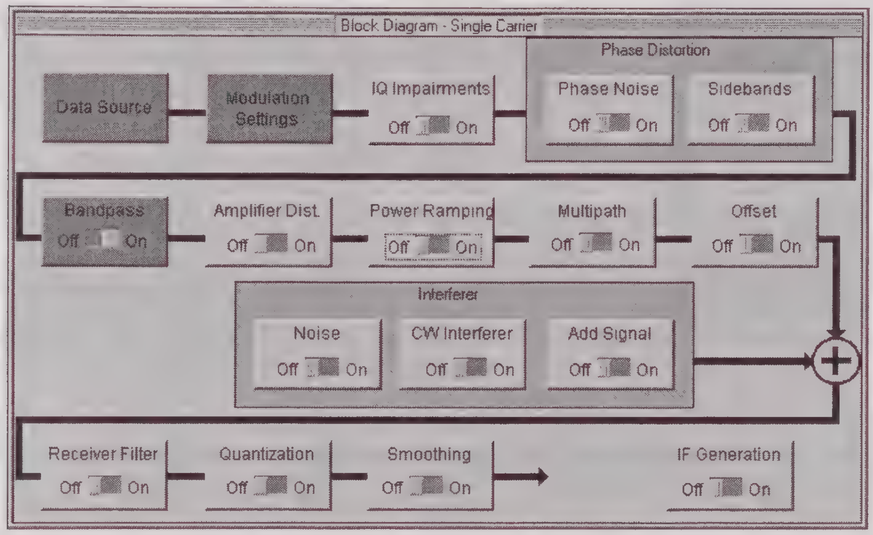


Fig. 5-6 Single-carrier block diagram with active bandpass panel.

When the setting panel of a block is already open, a click on the block activates the panel and positions it in the center of the screen.

All blocks in the diagram except the data source and modulation settings blocks (or the corresponding blocks for multicarrier, 3 GPP W-CDMA and IS-95) can be switched on and off. Thus an individual impairment scenario can be created. The on/off function can also be controlled from the block diagram. To this end a switch is provided in the lower part of each block, which can be actuated by means of the left mouse key. A click on Off or On sets the switch to the respective position. This switch is directly linked to the On/Off switch in the setting window of the block. When the switch in the setting window is actuated, the switch in the block diagram is set accordingly. The same applies the other way round (visible only when the setting panel is open).

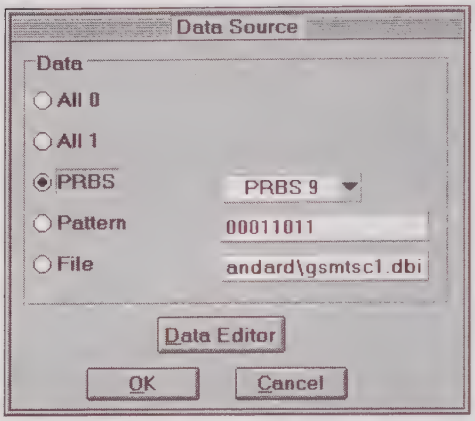
For a clear distinction of active and non-active blocks, the blocks are colour-coded. Active blocks (On) are displayed on a green background, non-active blocks (Off) on a grey one.

The Data Source and Modulation Settings blocks (eg carrier settings, 3 GPP W-CDMA configuration or IS-95 Configuration) cannot be switched on and off; they are always active and displayed on a green background.

The setting panels of the individual blocks are described in the following sections of this chapter in the order in which they are displayed in the diagram. In this chapter the blocks of the single-carrier transmission system are described, then those for the multicarrier, 3 GPP W-CDMA systems and IS-95 in separate chapters.

5.6 Data Source (Single Carrier)

The binary data source to be used for I/Q signal generation can be selected in the data source panel. Five different kinds of data sources are available: **All 0**, **All 1**, **PRBS**, **Pattern** and **File.** The desired data source can be selected by a mouse-click on the respective button.



Data Source

Data

○ All 0

○ All 1

● PRBS PRBS 9

○ Pattern 00011011

○ File andard\gsmtsc1.dbi

Fig. 5-7 Data Source panel

Description of data sources:

All 0: Data source All 0 sends a sequence of binary 0 symbols. An example is a data sequence with the length ten {d} = {0, 0, 0, 0, 0, 0, 0, 0, 0, 0}.

All 1: Data source All 1 sends a sequence of binary 1 symbols. An example is a data sequence with the length ten {d} = {1, 1, 1, 1, 1, 1, 1, 1, 1, 0}.

PRBS: This data source can generates different pseudo-random binary sequences.

PRBS 7, **PRBS 9**, **PRBS 11**, **PRBS 15**, **PRBS 16**, **PRBS 20**, **PRBS 21** and **PRBS 23** can be selected in the field at the right of the PRBS button.

The PRBS sources are defined by the CCITT V.52 or Rec. 0.151 standard.

The PRBS sequences are generated by a feedback shift register. The number following PRBS indicates the length of the generating shift register. For instance, a shift register with 16 memory cells is required for generating a PRBS 16 sequence. The PRBS generators of WinIQSIM produce binary pseudo-random bit sequences of different length and period, ie sequences that have a maximum length.

The feedback schemes for the individual PRBS types are shown below. The initial status of the shift register used by WinIQSIM is always 1 in register 0 and 0 in all other registers.

The generator for PRBS 9 with a feedback from registers 4 and 0 (output) is shown in the figure below.

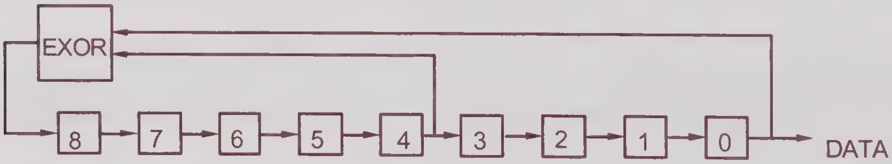


Fig. 5-8 Shift register for PRBS generation

The pseudo-random sequence of a PRBS generator is determined by the number of registers and the feedback. All available PRBS generators are listed in the table below:

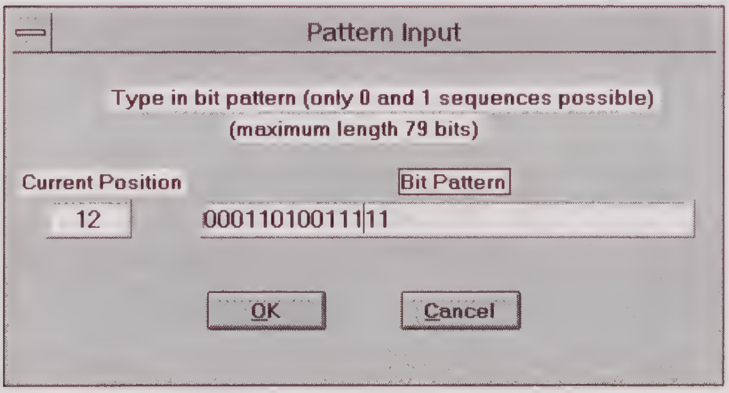
Table 5-2 Feedback points of PRBS generators

PRBS generator	Length in bits	Feedback from	Output sequence inverted
7 bit	$2^{7}-1 = 127$	Register 1, 0	No
9 bit	$2^{9}-1 = 511$	Register 4, 0	No
15 bit	$2^{15}-1 = 32767$	Register 1, 0	Yes
16 bit	$2^{16}-1 = 65535$	Register 5, 3, 2, 0	No
20 bit	$2^{20}-1 = 1048575$	Register 3, 0	No
21 bit	$2^{21}-1 = 2097151$	Register 2, 0	No
23 bit	$2^{23}-1 = 8388607$	Register 5, 0	Yes

For some PRBS generators, an inversion of the output bit stream is prescribed by the CCITT V.52 standard. In WinIQSIM the output sequences of the generators listed in the table with the option **Output sequence inverted: yes** are inverted as prescribed by the standard.

Pattern: A bit pattern can also be used as a data source. If a pattern with the length four {b} = {1, 1, 0, 1} is defined, a ten-bit data sequence of {d} = {1, 1, 0, 1, 1, 1, 0, 1, 1, 1} is obtained, for instance. The selected bit pattern is repeated until the desired data length is attained. If the bit pattern is longer than the required data sequence, only the first bits of the pattern are used.

The selected bit pattern is displayed at the right of the Pattern button. To change the pattern or to define a new one click on the bit pattern selection field with the left mouse key. The **Pattern Input** window is opened. It provides an editor for entering a bit pattern. The maximum length of the bit pattern is 79.



Type in bit pattern (only 0 and 1 sequences possible)
(maximum length 79 bits)

Current Position: 12

Bit Pattern: 00011010011111

Fig. 5-9 Pattern input panel

The bit pattern can be edited in the **Bit Pattern** entry field. A sequence of zeros and ones can be entered via the keyboard. Characters other than 0 and 1 are ignored. The current cursor position in the bit pattern is specified in the **Current Position** field at the left of the Bit Pattern field. The position information always starts with 0. Pattern components marked with the mouse can be overwritten or cleared (Cancel key or Delete). The Pattern Input panel is a modal window. It must be closed with OK or Cancel before other panels can be accessed.

When OK is pressed, the entered bit pattern is set and the panel closed. With Cancel pressed, the bit pattern is rejected and the panel is also closed. The previous bit pattern is retained.

File: A data file can also be used as a data source. The selected file is indicated in the field at the right of the File button. A click with the left mouse key on this field opens the File Select (popup) window where a data file can be selected. The extension used for such file is **.dbi** (for data bits). Other extensions are not permissible. The format of a data source file is described below.

Table 5-3 Format of a data file used as data source

Line	Content
1	ROHDE&SCHWARZ IQSIM DATA FILE
2	Comment line for entries
3	Sequence of 0 and 1 data bits as ASCII characters
...	...

The first data line contains the name ROHDE&SCHWARZ IQSIM DATA FILE to distinguish the file from other files. Any number of comment lines can be written before the first line. They must all start with #. These lines are followed by a compulsory comment line (without #). As from the third line, the actual information data follow as a sequence of 0 and 1 bits in the form of ASCII characters. All characters that are not 0 or 1 are ignored. The individual data values may be separated by blanks or commas as desired. The file may also contain line feeds or the like. Due to this flexibility, a data file compatible with WinIQSIM can be generated with almost any text editor. If the number of 0 and 1 bits is too small (less than 10% of the data entries), the file is rejected.

The data editor can also be called from the Data Source panel. It is a convenient tool for generating data files and described in section 5.7 below.

The Data Source panel can be quit with OK or Cancel (see section 5.4)

5.7 Data Editor

The data editor allows simple generation of binary input data sequences, particularly for TDMA (time domain multiple access) standards. These data sequences can be used as a signal source for computing I/Q signals.

Moreover, data sequences can be generated that can be used for bit error rate measurements with option AMIQ-B1. For detailed information please refer to chapter 6 BER Measurement with Option AMIQ-B1, where the function of the **BERT Settings** button is also described.

First the basic components of the data sequence, the data fields are defined. Following a modular principle, the data fields can be used to form the data structures of the various time slots and the slots for compiling the TDMA frames.

The data editor not only allows data to be created. It can also be used to define the power profile (power ramping) of the individual slots, the power/time templates.

When the data editor is called, it is automatically loaded with the previously stored settings so that operation can easily be continued.

The data editor can be called in the Data Source panel. It can also be called with the **Data: Data Editor** menu item or with the respective icon in the toolbar of the main panel.

The data editor and the steps required for the generation of data sequences are described in the following.

5.7.1 Data Editor Menu and Window

This section gives an overview of the individual menu items of the data editor and of the functions in the associated window. The setting windows pertaining to the menu items and buttons are described afterwards in a separate section.

Overview of operating menu

File		
	New	Resets the data editor to a defined start position. A new data sequence can be defined. All previously defined data structures are cleared. Starting with the data fields, all the elements of a data sequence can be newly configured.
	Open Settings	A configuration file with all settings of the data editor can be loaded. These configuration files have the fixed extension **.ded** (Data Editor). A comprehensive library of predefined data structures for the most common TDMA standards is supplied with WinIQSIM. With the aid of the data elements defined in this library, user-specific data sequences can be generated.
	Save Settings As	All settings made in the data editor, eg definition of data fields, can be stored in a file with the extension ***.ded.**
	Exit	The data editor is quit . Before the window is closed a query is displayed whether the current settings should be saved.
Configure		
	Data Fields	Selecting this menu item opens the **Configure Data Fields** panel where the basic components of the data sequence can be generated.
	Slots	Selecting this menu item opens the **Configure Slots** panel. Here the data structures of the different time slots can be prepared with the previously defined data fields. In this panel also the power/time templates of the slots can be configured and the markers output with the signal in the AMIQ can be set.

Frame	Calls the **Configure Frame** panel. One or several consecutive data frames are created in this panel with the aid of the defined slots.
Power Ramping	The **Power Ramping Settings** panel is displayed. The basic parameters of power control such as ramp type and duration as well as the various signal levels in the on and off state can be set in this panel.

Calculate

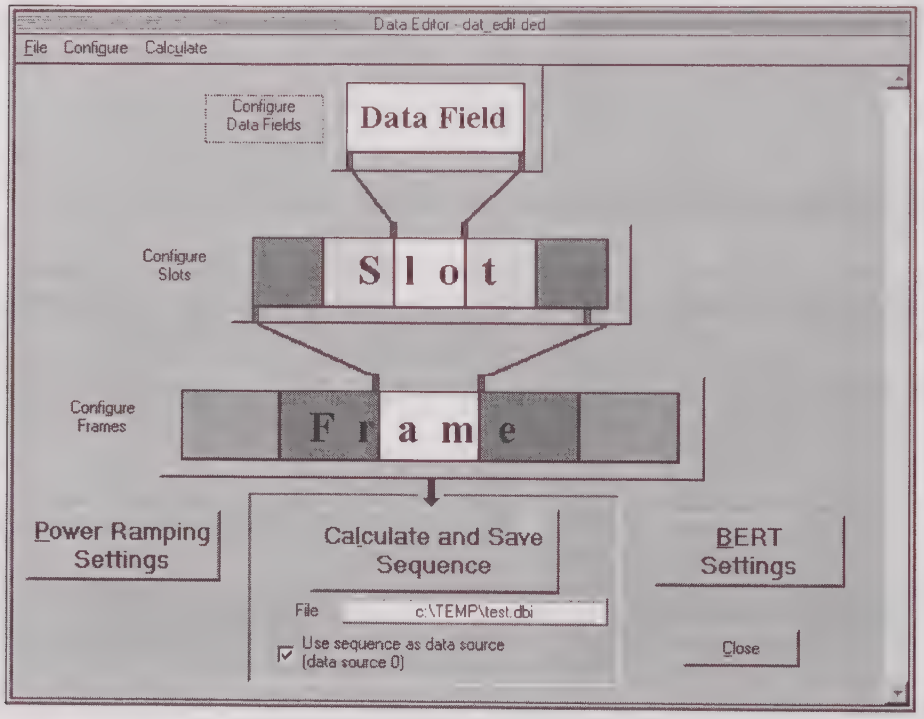
Calculate and save sequence	Selecting this menu item triggers a calculation of the data sequence and of power ramping with the settings defined. Before calculation is started, a file selection window is opened where a file with the fixed extension *.dbi (data bits) has to be specified for saving the calculated data sequence. The calculated data sequence may also be used as a data source for I/Q calculation.

Headline of data editor

The name of the currently edited configuration file is displayed in the headline of the data editor main panel. If a new data sequence is defined (File: New), **Data Editor - new** is displayed. When the new settings are stored, the file name in the headline is updated.

Operation using the sequence definition diagram

All setting windows of the data editor can also be called from the sequence definition diagram in the main panel of the data editor. The diagram illustrates the operating steps required for generating a data sequence. A click with the left mouse key on an element in the diagram opens the respective setting window.



Data Editor - dat_edit.ded

File c:\TEMP\test.dbi

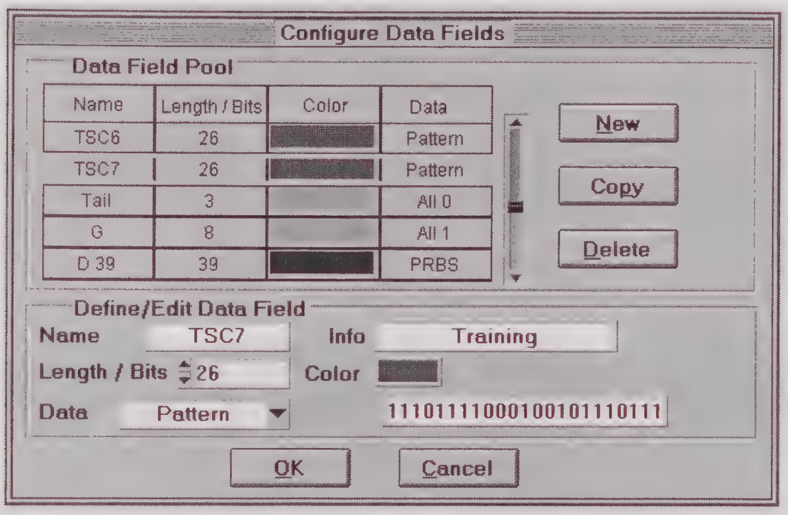
☑ Use sequence as data source (data source 0)

Fig. 5-10 Main panel of data editor

The setting windows of the data editor are displayed successively and not simultaneously. If the windows were displayed together, operation would be cumbersome because of the various interactions between the data structures. The menu selection line and the elements of the sequence definition diagram in the main panel are disabled when a setting window of the data editor is open.

5.7.2 Configure Data Fields Panel

In this panel the basic elements of the data sequence, the data fields are defined. Up to 50 different data fields can be generated. A data field is defined by its bit length and data content. To simplify identification and editing, a name and colour can be assigned to each data field. Furthermore, a brief comment can be given for each field.



Name	Length / Bits	Color	Data
TSC6	26	■	Pattern
TSC7	26	■	Pattern
Tail	3	□	All 0
G	8	□	All 1
D 39	39	■	PRBS

Name: TSC7
Info: Training
Length / Bits: 26
Color: ■
Data: Pattern
11101111000100101110111

Fig. 5-11 Configure Data Fields panel of data editor

Panel structure
The Configure Data Fields panel comprises two windows, the Data Field Pool with buttons and the Define/Edit Data Field window.

The **Data Field Pool** is a table where all predefined data fields are listed. It indicates the name, bit length, associated colour and data type of the individual data fields. With the aid of the scrollbar at the right of the table, the user can scroll through the table to view all defined data fields. The New, Copy and Delete buttons at the right of the table will be described further down.

In the **Define/Edit Data Field** window below the table, new data fields can be defined and existing ones edited.

5.7.2.1 Operation of Configure Data Fields Panel

When the panel is called up immediately after the selection of **File:New**, the data field pool is empty because no fields have been defined yet. If, on the other hand, a configuration file is loaded or data fields have been defined before, there are entries in the pool.

Selecting a defined data field from the pool
Click with the left mouse key on a data field in the list. The selected line is highlighted by an orange frame. The parameters of the selected field are automatically transferred to the Define/Edit window where the data field can be edited.

Editing/defining a data field
The data field selected in the data field pool (marked by an orange frame) can be edited in the Define/Edit Data Field window. Entries made in the Edit window are immediately transferred to the data field pool. When no field is selected in the pool, entries made in the Edit window do not have any effect.

A data field name of max. four characters can be entered in the **Name** field. A comment of max. 20 characters can be given in the **Info** field. The length of the data field in bits can be varied between 1 and 1000 in the **Length / Bits** field.

At the next level of data sequence definition in the Configure Slot panel, the data fields are graphically combined into slots. In this panel the fields are displayed as coloured elements labelled with name and bit length. To simplify identification, a colour can be assigned to the individual data fields in the **Color** field. To select a colour, click on the Color field with the left mouse key and hold the key down. A selection window is opened. Choose a colour with the mouse cursor while holding down the left mouse key. After having made your choice release the mouse key. The selected colour is indicated in the Color field. The colours should be assigned in a way to facilitate the definition of slots. Too many different colours will yield a confusing display. The configuration files supplied with WinIQSIM use the following colour code:

- Training sequences and sync words: red
- Fields containing information data (mostly called data): blue
- Guard intervals or ramps: grey

The main parameter of a data field is the information content which can be defined in the **Data** field. Four kinds of information data are available:

All 0: The data field is filled with a sequence of 0.

All 1: The data field is filled with a sequence of 1.

Pattern: Selecting this item opens a window where the bit pattern can be entered. The currently defined bit pattern is indicated in the data field which is filled with the bit pattern as described in section 5.6.

PRBS: This data source generates different pseudo-random binary sequences. **PRBS 9**, **PRBS 11**, **PRBS 15**, **PRBS 16**, **PRBS 20**, **PRBS 21** and **PRBS 23** can be selected in the Data selection field (see also section 5.6). A selection can also be made whether the PRBS sequence should be continuously repeated. In this case **Continued** is selected. Each of the seven PRBS generators is provided twice. The first generator resets its shift register each time the PRBS sequence is output to a data field (continued not selected). The second one stores the shift register status after the output of a PRBS sequence to a data field. When the generator is then called again, the previously started PRBS sequence is continued without interruption (continued). If the same PRBS source (eg PRBS 9) and Continued are selected for several data fields, the data for all fields are supplied by the same generator. The data content itself depends on the sequence in which the data fields are used later on.

Example:
Two data fields, D1 (length 5) and D2 (length 7), are configured with PRBS 9 Continued. The data fields in the slot (or frame) appear in the sequence D2, D1, D2. Assuming a generator output data sequence of {0,0,1,0,1,0,1,1,1,0,0,1,1,0,1,0,1,0,0,0,1,1,0,1, ...}, the fields contain the following data:

0	0	1	0	1	0	1	1	1	0	0	1	1	0	1	0	1	0	0	0	1	1
D2							D1					D2							...		

BERT-PRBS: This type of data can be used to generate a data sequence for bit error rate measurements with option AMIQ-B1. The PRBS type to be used is selected in the BERT Settings panel. See also Chapter 6 BER Measurement with Option AMIQ-B1.

Generating new data fields
Press the **New** button (at the right of the data field pool) to add a new data field. The pool table automatically scrolls to its lower end for the data field with the content name New, length 1, colour Grey and ALL 0. The entry is marked by an orange frame and transferred to the Edit field where the data field can be configured as desired (see description above).

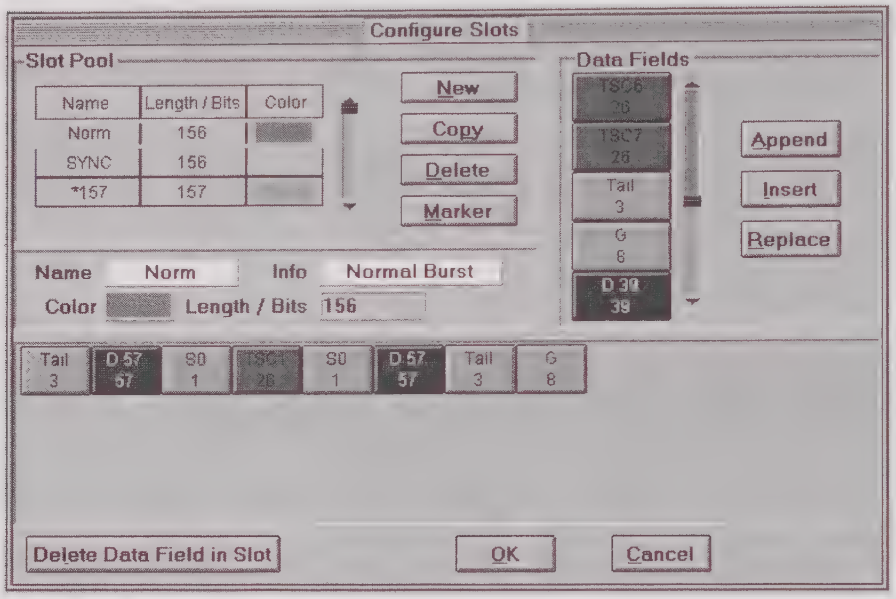
Copy function
With the **Copy** button next to the data field pool, defined data fields can be copied and from the copy a new data field created by a few modifications. The Copy button is only active when an entry has been selected in the data field pool (orange frame). The selected data field is copied and appended to the lower table end. The copied entry is assigned an orange frame and transferred to the Edit field where the copied data field can be modified as desired (see description above). This function is particularly useful when a great number of similar data fields is to be defined. The repeated entry of the same parameters can thus be avoided.

Delete function
A data field selected in the pool can be cleared with the **Delete** button at the right of the pool table. This button is only active when a data field is selected. Only data fields that are not in use at the slot level can be cleared. If an attempt is made to clear a data field in use, a respective message is issued.

The panel can be cleared with the **OK** and **Cancel** buttons. When the Cancel button is pressed, all changes made since the panel was called are discarded.

5.7.3 Configure Slots Panel

In this panel, slots are generated from the previously defined data fields. Up to 24 different slots can be defined. A slot is determined by its bit length and data content consisting of various data fields. To simplify identification and editing, a name and colour can be assigned to each slot. A brief comment can also be given for each slot.



Configure Slots

Slot Pool

Name	Length / Bits	Color
Norm	156	▨
SYNC	156	
*157	157	

Name: Norm
Info: Normal Burst
Color: ▨
Length / Bits: 156

Fig. 5-12 Configure Slots panel of data editor

Panel structure
The Configure Slots panel contains three windows. The first is the Slot Pool with the respective buttons, the second the Data Fields window and the third the workspace where slots are generated from the data fields.

The **Slot Pool** is a table where the already defined slots are listed. For a better overview, the name, bit length and the colour assigned to the individual slots are indicated in the table. With the aid of the scrollbar at the right of the table, the user can select the different parts of the table to view all defined slots. The New, Copy, Delete and Marker buttons at the right of the table will be described further down.

The **Data Fields** window contains a scrollable list of previously defined data fields and the buttons required for editing a slot.

In one section of the **slot workspace,** the name, a comment and the colour of a slot can be defined, in a second the slot can be assembled and graphically displayed.

5.7.3.1 Operation of Configure Slots Panel

When the panel is called immediately after the selection of **File:New**, the slot pool is empty because no slots have been defined yet. When a configuration file is loaded or slots have been defined before, there are entries in the pool.

Selecting a defined slot from the pool
Click with the left mouse key on a slot entry in the pool. The line selected in the pool is highlighted by an orange frame. The parameters of the selected slot are automatically transferred to the slot workspace. In addition to name, comment, slot colour and slot length, the data field structure of the slot is graphically displayed. The slot can then be edited in the workspace.

5.7.3.1.1 Editing/Defining a Slot

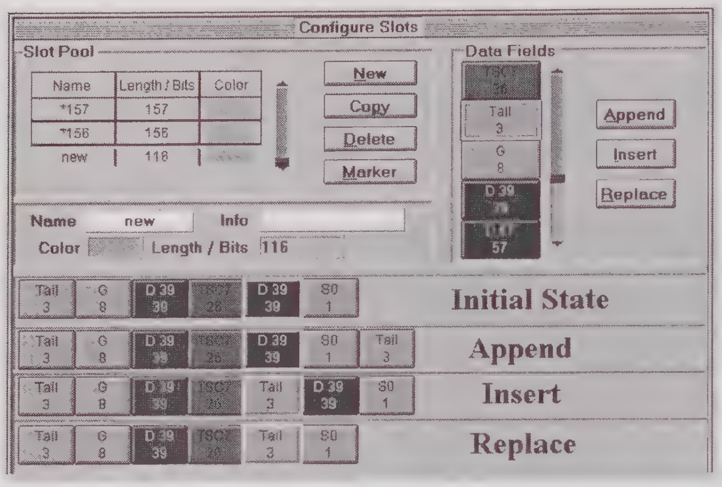
A slot selected in the pool (orange frame) can be edited in the workspace. Entries made in the workspace are immediately transferred to the slot pool. Without a slot selected in the pool, entries made in the workspace are ineffective and ignored.

A name of max. four characters can be assigned to the current slot in the **Name** field. A comment of max. 20 characters can be entered in the **Info** field.

At the next level of data sequence definition in the Configure Frame panel, the slots are combined into frames and graphically displayed. In this panel the slots are displayed as coloured elements labelled with name and bit length. To simplify identification, a colour can be assigned to the individual slots in the **Color** field. To select a colour click on the Color field with the left mouse key and hold the key down. A colour selection window is opened. With the left mouse key held down, a colour can be selected with the aid of the mouse cursor. Release the key after the selection. The selected colour is indicated in the Color field.
The length of the slots in bits is displayed in the **Length / Bits** field. The length is determined by the data field structure of the slot and cannot be edited.

In the lower part of the workspace the slot structure (data fields) is graphically displayed.
A data field can be selected in the slot by a click with the left mouse key. The selected data field is highlighted by an orange frame. Now the **Data Fields** window is used. In this window the slot structure can be configured, ie data fields can be inserted, appended or replaced.

Data Fields window
In this section the data field to be used next in the current slot can be selected from the list with the aid of the left mouse key. The selected data field is highlighted by an orange frame. The data field in the list can be used as often as desired. With the **Append** button the selected data field is added to the end of the slot. The **Insert** button inserts the data field selected in the list at the left of the data field marked in the slot. When the **Replace** button is pressed, the data field marked in the slot is replaced by the data field selected in the list. The figure below illustrates the function of the Append, Insert and Replace buttons.



Name	Length / Bits	Color
*157	157	
*156	156	
new	116	

Name new
Info
Color
Length / Bits 116

Fig. 5-13 Function of buttons in the data field window

A data field selected in the slot can be cleared with the **Delete Data Field in Slot**.

A slot may contain up of up to 36 data fields. In the workspace a slot containing more than 12 data fields is displayed in two lines, a slot with more than 24 data fields takes up three lines.

5.7.3.1.2 New, Copy and Delete

The New, Copy and Delete buttons in the Slot Pool window have a similar function to those in the Configure Data Fields panel.

Generating new slots
Press the **New** button (at the right of the Slot Pool) to add a new slot to the pool. The pool table automatically scrolls to its lower end where a slot with the name New, length 0, colour Grey and ALL 0 is located. This entry in the table is marked by an orange frame and transferred to the Slot workspace. The graphics section of the workspace is still empty. At first the slot contains no data fields but it can be configured as desired (see description above).

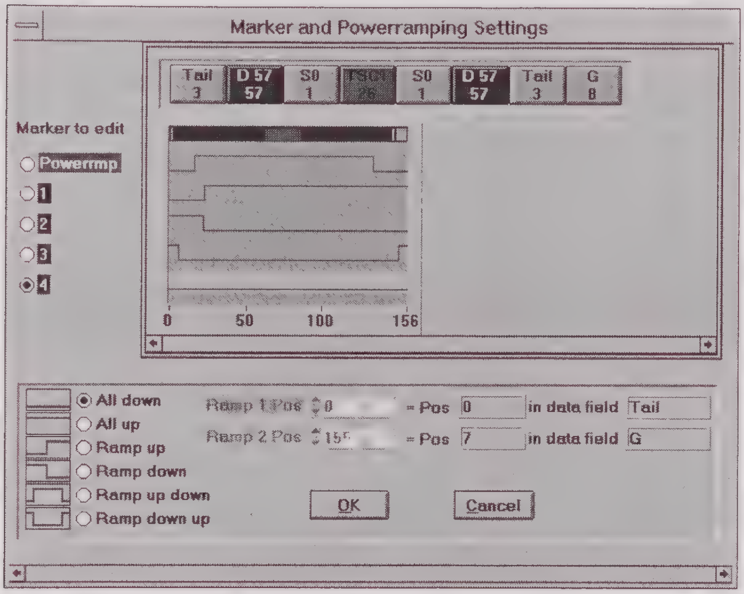
Copy function
With the **Copy** button, defined slots can be copied and from the copy a new slot can be created by a few modifications. The Copy button is only active when an entry has been selected in the slot pool (orange frame). The selected slot is copied and appended to the lower table end. The copied entry in the table is highlighted by an orange frame and transferred to the Slot workspace where the copied slot can be modified as desired (see description above). This function is particularly useful if a number of similar slots is to be defined that differ only by the training sequence, for instance. The repeated entry of the same parameters can thus be avoided.

Delete function
A slot selected in the pool can be cleared using the **Delete** button (at the right of the pool table). This button is only active when a slot is selected. Only slots not in use at the frame level can be cleared. If an attempt is made to clear a slot used at the frame level, a respective message is issued.

5.7.3.1.3 Markers

AMIQ is provided with four marker channels in addition to the four I/Q outputs. At these channels control signals are output eg for triggering or external power ramping of the I/Q signal. The characteristics of the four marker channels of a slot can be defined at the data bit level in the data editor. A power time template can be defined in addition to the marker structure.

To perform these settings, select a slot from the slot pool and press the **Marker** button at the right. The following **Marker and Power Ramping Settings** panel is displayed.



Marker to edit

○ Powerrmp
○ 1
○ 2
○ 3
● 4

● All down
○ All up
○ Ramp up
○ Ramp down
○ Ramp up down
○ Ramp down up

Ramp 1 Pos 0 = Pos 0 in data field Tail
Ramp 2 Pos 155 = Pos 7 in data field G

Fig. 5-14 Marker and Power Ramping Settings panel

The structure of the current slot is displayed again in the upper part of the panel.

A diagram (marker graph) is displayed directly below. It shows the currently defined power-time template and the four marker channels. One marker channel only or the power-time template can be edited at a time. One of the five channels under **Marker to edit** at the left of the graph should be selected for editing. The marker characteristics are displayed sequentially in the order of the channels listed under Marker to edit (power ramping or power-time template first and then the markers 1 to 4).

All data fields displayed in the slot workspace and in the upper window of this panel have the same length irrespective of their bit length. In the marker graph, on the other hand, the slot structure is shown. Here the length of the data fields corresponds to the bit length. The data fields are not labelled. The section to be displayed can be selected with the scrollbar below the marker graph.

Marker 1 is a special case. It can be automatically coupled to the power-time template (see section Power Ramping Settings) and used later for controlling external power ramping of the I/Q signal. In this case the marker button 1 is disabled and **Coupled to power ramping** is displayed.

In the following description the terms marker channel and marker characteristic will be used. A difference will not be made between marker and power-time template.

Determining the marker characteristic

A marker channel can assume the values 0 or 1. Before the marker characteristic of a selected channel can be defined, the type of the characteristic must be determined. Six different types can be selected at the left below the panel.

Table 5-4 Overview of marker characteristics

Symbol	Name	Meaning
All down	All down	The marker channel in the slot has always the value 0.
All up	All up	The marker channel in the slot has always the value 1.
Ramp up	Ramp up	The marker channel of the slot has at first the value 0 and then changes to 1. Any point within the slot can be defined for the transition.
Ramp down	Ramp down	The marker channel of the slot has at first the value 1 and then changes to 0. Any point within the slot can be defined for the transition.
Up - Down	Ramp up down	The marker channel of the slot has at first the value 0 and then changes to 1 and back again to 0. The two transition points within the slot can be set as required.
Down - Up	Ramp down up	The marker channel of the slot has at first the value 1, changes to 0 and back again to 1. The two transition points within the slot can be set as required.

The marker characteristic can be determined graphically by means of the cursor in the marker graph or by entering a ramp and transition point in the field below.

No further information is required for defining the **All down** and **All up** characteristics. The entry fields for **Ramp 1 Pos** and **Ramp 2 Pos** are disabled, a cursor is not displayed in the marker graph.

A transition point has to be defined for **Ramp up** and **Ramp down.** The entry field for Ramp 1 Pos is enabled. Here the transition point can be set at the bit level in the range from 0 to slot length -1, ie counting of data bits starts at 0. The transition point in the slot is also converted to a position in the data field in which the transition occurs. The position in the data field and the name of the field are also displayed. This function makes counting of bits unnecessary when for instance a marker change is to be triggered at the third position of a data field in the slot.

The transition point can also be set in the marker graph by shifting the displayed cursor. This allows a rough determination of the ramp position. If necessary, accurate setting is possible in the Ramp 1 Pos entry field. When the Ramp 1 position is changed, the cursor position is adapted and vice versa.

Two transition points have to be entered for **Ramp up down** and **Ramp down up.** The Ramp 2 Pos field is enabled in addition to the Ramp 1 Pos field. Two cursors are available in the marker graph for defining the transition point. Setting the transition points by means of entries and cursors is identical to the setting of a position described above. Care should be taken that the first transition point comes before the second as otherwise an error message will be output.

With the marker characteristics of all channels configured, the panel can be quit with **OK.** If the modified marker characteristics should not be retained, the panel can be quit with **Cancel**. In this case all modifications are discarded.

With all slots and associated marker characteristics defined, close the Configure Slots panel with **OK** and start defining the frames. Press the **Cancel** button if the changes made in the Slot panel should not be saved.

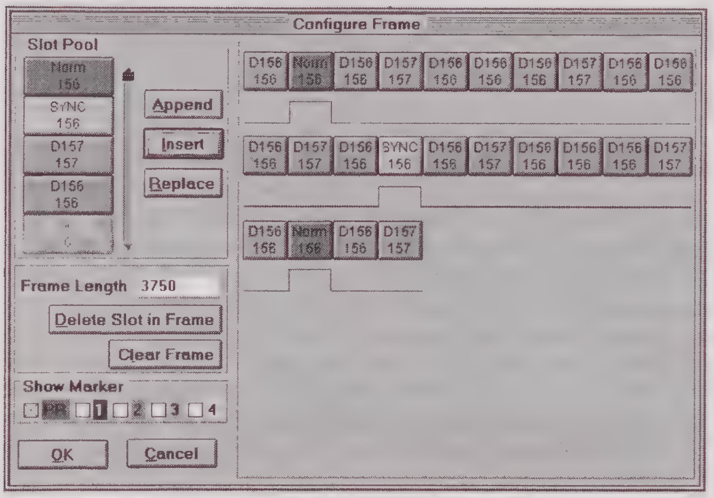
5.7.4 Configure Frame Panel

One or several consecutive frames can be configured with the previously defined slots. Up to 50 frames can be combined to a frame.

Panel structure

The Configure Frame panel consists of three windows. The first is the **Slot Pool** with associated buttons. The slot pool is a table where defined slots are listed. Name and bit length of the individual slots are indicated in the table. With the aid of the scrollbar at the right of the table the user can select the different parts of table section to view all defined slots. The Append, Insert and Replace buttons at the right of the table will be described further down.

The second window is the **frame workspace** where the slots are combined and graphically displayed.



Slot Pool:

Norm 156
SYNC 156
D157 157
D156 156

Frame Length 3750

D156 156	Norm 156	D156 156	D157 157	D156 156	D156 156	D156 156	D157 157	D156 156	D156 156
D156 156	D157 157	D156 156	SYNC 156	D156 156	D157 157	D156 156	D156 156	D156 156	D157 157
D156 156	Norm 156	D156 156	D157 157						

Fig. 5-15 Configure Frame panel of data editor

Editing the frame

The structure (slots) of the frame is graphically displayed in the frame workspace.
A slot of the frame can be selected by a click with the left mouse key. The selected slot is highlighted by an orange frame. Further actions are then made in the **Slot Pool** section, where the frame structure can be configured and slots inserted, appended or replaced.

In the slot pool the slot to be used next in the frame can be selected from the list with the aid of the left mouse key. The selected data field is highlighted by an orange frame. All slots in the list can be used as often as desired. With the **Append** button, the selected slot is added to the end of the frame. The **Insert** button inserts the slot selected in the list at the left of the field marked in the frame. With the **Replace** button the slot selected in the frame is replaced by one selected in the slot list.

The frame length in bits, which is the sum of the employed slot lengths, is displayed in the **Frame Length** field. This field cannot be edited.
A slot selected in the frame can be cleared with the **Delete Slot in Frame** button. For clearing the whole workspace press the **Clear Frame** button.

A frame may contain up to 50 slots. Depending on its number of slots, the frame is displayed in the workspace in up to five lines of max. ten slots each.

Show Marker
In the Show Marker field the user can select whether and which of the defined marker channels should be displayed. The characteristic of the selected channels is then displayed below the slots of the frame. The colours of the marker graphs correspond to the colours of the marker selection labels (power ramping red, marker 1 blue, marker 2 green, marker 3 turquoise, marker 4 yellow). The space between the frame lines is assigned to the selected markers.

After defining the frame, the panel can be quit with **OK.** When the panel is quit with **Cancel,** all the modifications are discarded.

The completely defined data sequence and the associated marker lists can now be computed. The calculation is described in the following section.

5.7.5 Calculation of Data Sequence and Marker Lists

After data fields have been defined, slots combined and marker channels with power-time templates determined and configured into a frame, the final task can be performed. The data sequence to be used as a data source for I/Q calculation must now be computed from the defined data field, slot and frame structures with marker lists.

First enter in the File field under Calculate and Save Sequence the file with the fixed extension ***.dbi** (data bits) in which the calculated data sequence is to be saved. Select in the Use Sequence as Data Source field whether the calculated data sequence is to be used as the current data source. The calculated data file is then automatically entered as a data source in the Data Source panel (Data Source: File).

Press now the **Calculate and save sequence** in the sequence definition diagram or select the respective item in the Calculate menu. During the calculation, a progress indication bar informs the user on the state of the calculation.

The generated marker lists defined at the bit level in the data editor are converted to the sampling level and entered in the Marker Setting panel.

When the Internal Power Ramping option is selected in the Power Ramping Settings panel, the table in the Power Ramping panel is also filled with the calculated power ramping characteristic. In this case the ramp points referenced to the data bits are to be converted to the symbol level.

Note: *The conversion of marker and ramp positions from the data bit level to the sample or symbol level depends on the currently selected oversampling and modulation levels. To avoid discrepancies, the levels should be determined before data and markers are calculated.*

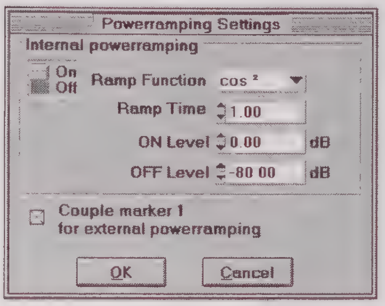
Example: *Bit position 104 corresponds to symbol position 52 in the case of a two-level modulation like QPSK and to symbol position 26 with the four-level modulation 16QAM.*

If oversampling is lower than the modulation level, inaccuracies may occur when marker lists are converted to the sample level and adjacent marker entries are too close to each other.

When the calculated data sequence is ready for use but should not be employed as the current data source, the calculated file may be called later on as a data source under File in the Data Source panel. In this case the defined marker positions and power ramping cannot be used however. This function is only available at the time when the data and marker lists are calculated.

5.7.6 Power Ramping Settings Panel of Data Editor

Power ramping and the power-time template can be set in the Power Ramping Settings panel. At first the settings only apply to the current configuration in the data editor. Other parts of the program (particularly the Power Ramping panel and the Marker Settings panel) are only affected when data and power ramping lists are computed and used.



On / Off: Off

Ramp Function: cos ²

Ramp Time: 1.00

ON Level: 0.00 dB

OFF Level: -80 00 dB

☐ Couple marker 1 for external powerramping

Fig. 5-16 Power Ramping Settings panel of data editor

Internal Power Ramping

In this section, WinIQSIM-internal power ramping can be configured using the data editor. With the aid of the **On/Off** switch it can be decided whether power ramping defined in the data editor (power-time templates of slots) should be used for filling the tables of the Power Ramping panel, and thus for power control of the calculated signal, after calculation and direct use of a data editor file.

The type of power ramping and the ramp time can be defined in the **Ramp Function** and **Ramp Time** fields. A selection can be made between a cosine square function and a linear ramp function. A ramp time between 0 to 16 T_{symbol} can be set normalized to the symbol period. Also fractions of the symbol period can be set.

The signal levels to be assigned to the power ramping marker states 0 (Off) and 1 (On) can be varied between -80 dB and 0 dB in the **ON Level** and **OFF Level** fields.

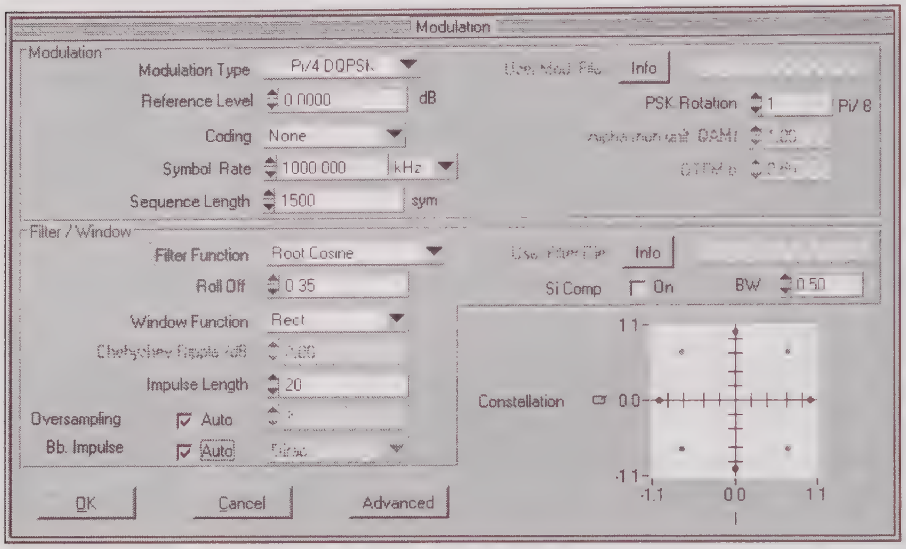
External Power Ramping

By selecting **Couple Marker 1 for External Power Ramping,** the marker channel 1 is directly linked to the power ramping marker. To further expand the dynamic range, for instance, the power of the I/Q signal can also be controlled externally by means of the output signal of marker channel 1.

The panel can be quit as usual with the **OK** or **Cancel** button. With Cancel all modifications made are discarded.

5.8 Modulation Settings Panel

The Modulation Settings panel can be used in the single-carrier and multicarrier mode. All modulation parameters of the signal are defined in this panel.



Modulation

Modulation Type: Pi/4 DQPSK

Reference Level: 0.0000 dB

Coding: None

Symbol Rate: 1000.000 kHz

Sequence Length: 1500 sym

PSK Rotation: 1 Pi/ 8

Filter / Window

Filter Function: Root Cosine

Roll Off: 0.35

Si Comp ☐ On

BW: 0.50

Window Function: Rect

Impulse Length: 20

Oversampling ☑ Auto

Bb. Impulse ☑ Auto

Fig. 5-17 Modulation Settings panel

The parameters defined in this panel are described below. The availability of some entry fields in the panel depends on the settings made in other fields. So, entering window parameters is not useful when a window function is selected for which no parameters have to be defined. Irrelevant entry fields are automatically displayed in grey. Most of them can be read but cannot be operated.

5.8.1 Type of Modulation

This is the most important parameter of the panel. The selected type is indicated in the **Modulation Type** field. A click with the left mouse key on the field opens a two-level selection menu where the new type of modulation can be set.

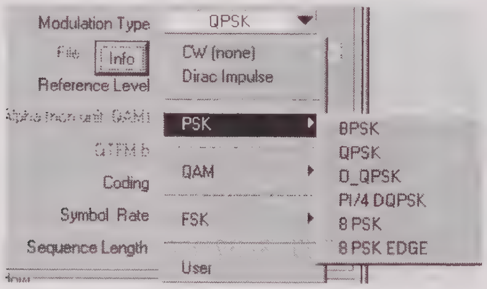


Fig. 5-18 Two-level modulation type selection menu

Definition of terms

Before describing the modulation types, a few terms shall be defined that will be used in the description.

Modulation mapping	Representation of the binary input data vector to a modulation status.
Modulation level	Number of input data bits defining a modulation status. For instance, the level of 8PSK is three.
Mapping table	Tabulated mapping order for assigning a sequence of m input data bits (m = level of modulation) to a phase shift in the case of PSK, to a value pair at the complex level with QAM and to a frequency offset with FSK.
Constellation diagram	Graphical representation of permissible modulation states at the I/Q level.

The selectable modulation types and the respective mapping are described below. The constellation diagram is often displayed in addition to the mapping table.

CW (none): With this item selected, a continuous wave signal is obtained. The in-phase (I) component and the quadrature (Q) component of the signal are constant (in WinIQSIM: I = 1, Q = 0). A pure, unmodulated carrier signal is thus obtained.

Dirac pulse: The transmission system is excited with a true Dirac pulse (Kronecker delta). This allows the impulse response of the whole transmission system to be determined. This modulation type can also be used, for instance, for determining the impulse response of a filter (provided all other components in the transmission path are switched off).

The function of a digital Dirac pulse corresponds to $\delta(n) = \{1 \text{ for } n = 0, 0 \text{ for others.}\}$

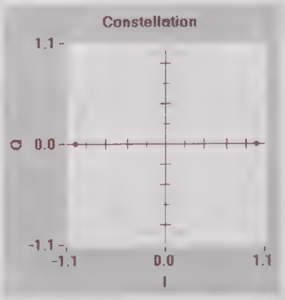
The following modulation types are arranged in groups. The first group contains phase shift keying (**PSK**), the next quadrature amplitude modulation (**QAM**) and the last all the methods using frequency shift keying (**FSK**).

PSK modulations
WinIQSIM supports 6 types of PSK modulation: BPSK, QPSK, Offset QPSK, $\pi/4$ DQPSK, 8 PSK and 8 PSK EDGE.

BPSK: With binary phase shift keying, two different start phases are assigned to the binary input data. Phase 0° is assigned to input data bit 0 and phase 180° to input bit 1.

Table 5-5 Mapping of BPSK

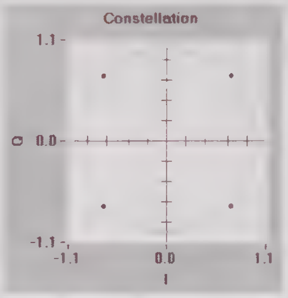
Data symbol	Phase
0	0°
1	180°



QPSK: Quadrature phase shift keying also called 4PSK is a two-level modulation mode. A data symbol consisting of two input bits is assigned to one of four modulation states. For details refer to the mapping table below.

Table 5-6 Mapping of QPSK

Data symbol	Phase
00	45°
01	135°
10	225°
11	315°



Offset QPSK: Offset QPSK uses the same mapping as QPSK with the sole difference that the transition from one modulation state to another is performed in two steps. The I component is shifted first and after half a symbol the Q component. To obtain optimum results, even-numbered oversampling should be selected to avoid interpolation when the Q components are delayed.

The advantage of Offset QPSK over QPSK is that zero-crossings do not occur at the origin of the complex level when the modulation status changes by 180°. 100% amplitude modulation can thus be avoided. The diagrams below compare the status transition from 00 to 10 for QPSK and for Offset QPSK (the use of a rectangular filter and window function is assumed).

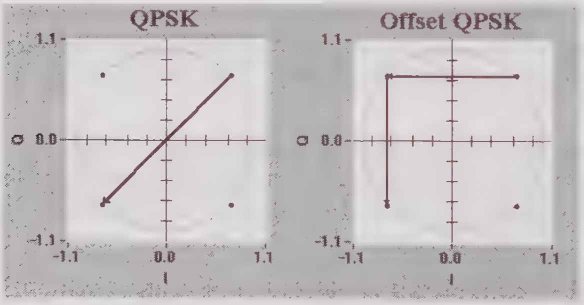


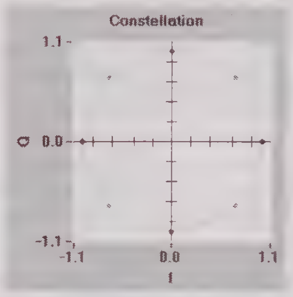
Fig. 5-19 Comparison of status transitions with QPSK (left) and Offset QPSK (right)

When an suitable filter is used, the transition between two states can be performed almost entirely on the unit circle. As a result the signal amplitude remains almost constant.

π/4 DQPSK: π/4-shifted differentially encoded QPSK is a differential 4-phase modulation with an additional phase shift of π/4 at each modulation step. With differential phase modulation, the transferred information is contained in the difference of the absolute phases of consecutive symbols. The assignment of data symbols to phase differences is shown below.

Table 5-7 Assignment of data symbols to phase differences with π/4 DQPSK

Data symbol	Phase difference
00	45°
01	135°
10	225°
11	315°



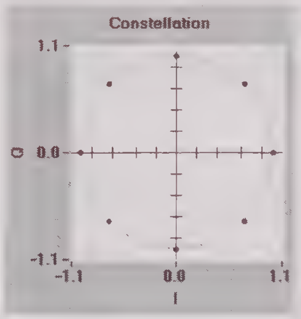
Due to the additional phase shift of π/4 (45°), this modulation assumes eight different states in the constellation diagram. Four states for the even-numbered symbol intervals (0, 2, 4, ...) and four for the odd-numbered intervals (1, 3, 5, ...).

The benefit of π/4 DQPSK modulation is that phase transitions of +π or -π do not occur. Same as with Offset QPSK, a more constant signal amplitude is thus obtained.

8 PSK: 8PSK is a three-level phase modulation which assigns one of eight possible modulation states to three binary input bits.

Table 5-8 Mapping of 8PSK

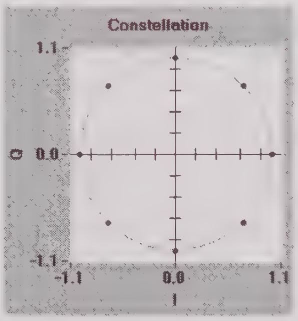
Data symbol	Phase
000	0°
001	45°
010	90°
011	135°
100	180°
101	225°
110	270°
111	315°



8 PSK EDGE: 8 PSK EDGE is a special type of the three-level PSK suggested by ETSI for the extension of GSM (GSM EDGE: Enhanced Data Rates for GSM Evolution) . One of eight possible modulation states is assigned to three binary input bits.

Table 5-9 Mapping 8 PSK EDGE

Data symbol	Phase
000	135°
001	180°
010	90°
011	45°
100	270°
101	225°
110	315°
111	0°



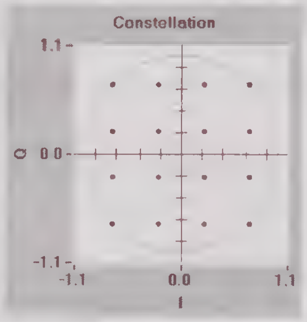
QAM

Quadrature amplitude modulation is the second large modulation group. QAM uses phase and amplitude modulation. A modulation status or modulation symbol represents several input data bits. With 64QAM, for instance, a modulation symbol represents six input data bits. The transmission rate of these symbols is lower than the bit rate by a factor of six. WinIQSIM supports the following QAM modes: 16QAM, 32QAM, 64QAM and 256QAM.

16QAM: 16QAM is a four-level modulation with 16 phase/amplitude states. The first two input data bits denominate the quadrant of the respective modulation symbol at the complex level (00: first quadrant, top right; 10: second quadrant, top left; 11: third quadrant, bottom left; 01: fourth quadrant, bottom right). The last two input data bits denominate the position of the modulation symbol in the quadrant. The following table shows the mapping of input data bit sequences into complex modulation states. The I (real) and Q (imaginary) components of the modulation status are also given.
Mapping of 16QAM is according to (DVB) ETS 300 429 standard (Digital Video Broadcasting for Cable Systems).

Table 5-10 Mapping of 16QAM

Data symbol	I component	Q component
0000	1/6 √2	1/6 √2
0001	1/2 √2	1/6 √2
0010	1/6 √2	1/2 √2
0011	1/2 √2	1/2 √2
0100	1/6√2	-1/6√2
0101	1/6 √2	-1/2 √2
0110	1/2 √2	-1/6 √2
0111	1/2 √2	-1/2 √2
1000	-1/6 √2	1/6 √2
1001	-1/6 √2	1/2 √2
1010	-1/2 √2	1/6 √2
1011	-1/2 √2	1/2 √2
1100	-1/6 √2	-1/6 √2
1101	-1/2 √2	-1/6 √2
1110	-1/6 √2	-1/2 √2
1111	-1/2 √2	-1/2 √2

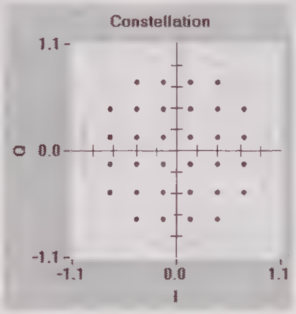


32QAM: 32QAM is a five-level modulation with 32 phase/amplitude states. The two most significant bits (top left) of a data symbol again denominate the quadrant of the respective modulation symbol at the complex level (00: first quadrant, top right; 10: second quadrant, top left; 11: third quadrant, bottom left; 01: fourth quadrant, bottom right). The last three input data bits denominate the position of the modulation symbol in the quadrant. The following table shows the assignment of input data bit sequences to the complex modulation states. The modulation status of the I (real) and Q (imaginary) signal is also given. Only the modulation symbols of the first quadrant are shown. The symbols of the other quadrants are obtained by rotating the first quadrant by 90°, 180° or 270°.

Mapping of 32QAM is according to (DVB) ETS 300 429 standard (Digital Video Broadcasting for Cable Systems).

Table 5-11 Mapping of 32QAM

Data symbol	I part	Q part
00000	3/10 √2	1/2 √2
00001	1/10 √2	1/10 √2
00010	3/10 √2	1/10 √2
00011	1/2 √2	1/10 √2
00100	1/10 √2	1/2 √2
00101	1/10 √2	3/10 √2
00110	3/10 √2	3/10 √2
00111	1/2 √2	3/10 √2

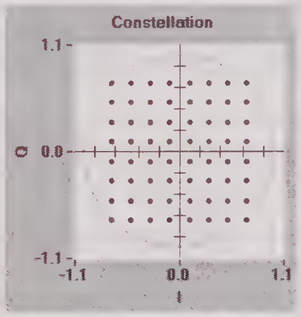


64QAM: 64QAM is a six-level modulation with 64 phase/amplitude states. The two most-significant (left-most) bits of a data symbol denominate the quadrant of the modulation symbol at the complex level (00: first quadrant, top right; 10: second quadrant, top left; 11: third quadrant, bottom left; 01: fourth quadrant, bottom right). The four subsequent input data bits denominate the position of the modulation symbol in the quadrant. The following table shows the assignment of input data bit sequences to the complex modulation states. The I (real) and Q (imaginary) components of the modulation status are also given. Only the modulation symbols of the first quadrant are shown. The symbols of the other quadrants are obtained by rotating the first quadrant by 90°, 180° or 270°.

Mapping of 64QAM is according to (DVB) ETS 300 429 standard (Digital Video Broadcasting for Cable Systems).

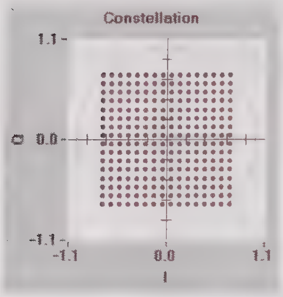
Table 5-12 Mapping of 64QAM

Data symbol	I part	Q part
000000	1/14 √2	1/14 √2
000001	3/14 √2	1/14 √2
000010	1/14 √2	3/14 √2
000011	3/14 √2	3/14 √2
000100	1/2 √2	1/14 √2
000101	5/14 √2	1/14 √2
000110	1/2 √2	3/14 √2
000111	5/14 √2	3/14 √2
001000	1/14 √2	1/2 √2
001001	3/14 √2	1/2 √2
001010	1/14 √2	5/14 √2
001011	3/14 √2	5/14 √2
001100	1/2 √2	1/2 √2
001101	5/14 √2	1/2 √2
001110	1/2 √2	5/14 √2
001111	5/14 √2	5/14 √2



256QAM: 256QAM is an eight-level modulation with 256 phase/amplitude states. The two most-significant (left-most) bits of a data symbol denominate the quadrant of the respective modulation symbol at the complex level (00: first quadrant, top right; 10: second quadrant, top left; 11: third quadrant, bottom left; 01: fourth quadrant, bottom right). The six subsequent input data bits denominate the position of the modulation symbol in the quadrant. The mapping of input data bit sequences into complex modulation states is not shown in a table to avoid confusion. The modulation symbols in the first quadrant assume all combinations of {1/30√2, 3/30√2, 5/30√2, 7/30√2, 9/30√2, 11/30√2, 13/30√2, 1/2√2} for the I and Q signal. The symbols of the other quadrants are again obtained by rotating the first quadrant by 90°, 180° or 270°.

Mapping of 256QAM is according (DVB) ETS 300 429 standard (Digital Video Broadcasting for Cable Systems).



FSK

The third and last group are the digital frequency modulation modes, frequency shift keying (FSK). With FSK the frequency of the input symbols is shifted. WinIQSIM supports the following FSK modes: MSK, 2FSK, 4FSK and GTFM.

The modulation index h of digital frequency modulation is defined as

$$h = 2 \cdot \frac{\Delta f}{f_{symbol}} \qquad \text{where } \Delta f = \text{ frequency deviation.}$$

The frequency deviation is derived as

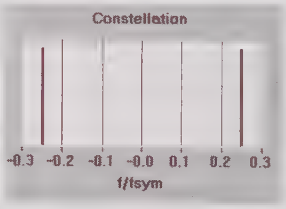
$$\Delta f = \frac{h}{2} \cdot f_{symbol}$$

The modulation and FSK index can be used for varying the frequency deviation. In WinIQSIM this parameter can also be set (see **FSK Index** in this section).

MSK: Minimum shift keying is a digital frequency modulation permitting two frequency shifts. The modulation index (FSK Index) of MSK is permanently fixed to 1/2. The FSK index cannot therefore be changed for MSK. The frequency deviation of MSK is set to ¼ of the symbol rate.

Table 5-13 Mapping of MSK

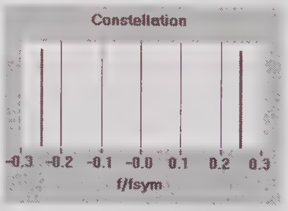
Data symbol	Frequency
0	-Δf
1	Δf



2FSK: 2 frequency shift keying is a digital frequency modulation with two frequency states. With 2FSK the modulation index (FSK Index) can be selected. The frequency deviation is defined according to the above formula.

Table 5-14 Mapping of 2FSK

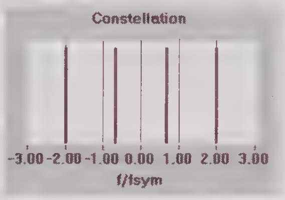
Data symbol	Frequency
0	-Δf
1	Δf



4FSK: 4 frequency shift keying is a four-state digital frequency modulation. With 4FSK the modulation index (FSK Index) can be selected. The frequency deviation is calculated according to the above formula. The relationship between data symbols and frequencies is shown in the following table.

Table 5-15 Mapping of 4FSK

Data symbol	Frequency
00	-Δf
01	-Δf/3
10	Δf/3
11	Δf



GTFM: Same as with MSK, with generalized tamed frequency modulation (GTFM) the phase is shifted by 90° within a data symbol. In contrast to MSK, the phase change of 90° is spread over three consecutive bit periods. The spread of the phase change to the bit periods is controlled by the weighting factor b.

User modulation: To allow also new modulation types to be used that are not predefined by WinIQSIM, a user-specific modulation type can be configured via a data file. When User Modulation is selected, a window is opened where a file with the extension ***.IMP** (IQSIM mapping file) can be selected. The user modulation file must be an ASCII file of the following format.

Table 5-16 Format of user modulation file

Line	Content		
1	ROHDE&SCHWARZ IQSIM MAPPING FILE		
2	Comment line with any kind of entries		
3	PSK	QAM	FSK
4	0 (no offset of I/Q signal) or 1 (offset of IQ signal)	0 (no offset of I/Q signal) or 1 (offset of IQ signal)	0
5	Number of modulation states	Number of modulation states	Number of modulation states
6	I value, Q value for data symbol 0	I value, Q value for data symbol 0	Standard frequency change for data symbol 1
7	I value, Q value for data symbol 1	I value, Q value for data symbol 1	Standard frequency change for data symbol 1
8	Cont'd for all modulation states	Cont'd for all modulation states	Cont'd for all modulation states

The first data line gives the name ROHDE&SCHWARZ IQSIM MAPPING FILE to distinguish user files. Any number of comment lines can be written before the first line. They must all start with #. These lines are followed by a compulsory comment line (without #). Subsequently it has to be decided whether PSK, QAM or FSK modulation should then be defined. With PSK and QAM modulation, the following line determines whether an offset of the Q signal should be used (1) or not (0) in bit 0 (weighting 1). Bit 2 (weighting 2) decides about differential coding.

The number of modulation states must be specified for all types of modulation. Up to 4,096 modulation states may be contained in the file. With PSK and QAM, the following lines specify the pairs of I/Q values assigned to a data symbol. Only one pair is specified in each line, separated by a comma. This is continued until all modulation states are defined. The I/Q values are to be defined in the logical order of the assigned data symbols. First the I/Q values for data symbol 0 (000...000), then that for data symbol 1 (000...001), etc.
It should be noted that the maximum amplitude of the vector defined by an I/Q pair should not exceed 1.

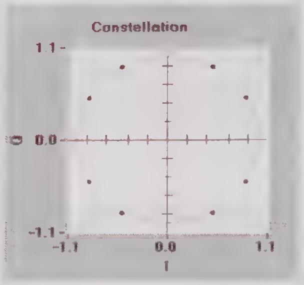
$$r = \sqrt{I^2 + Q^2} \leq 1$$

The procedure is the same for FSK with the difference that a frequency shift normalized to the symbol rate is specified instead of the I/Q pair.

The selected user modulation file is displayed in the **File** field below the Modulation Type selection field. To select another modulation file, click into the file field with the left mouse key. The described file selection window is opened and another modulation file can be selected.

A user modulation file for a special 8PSK modulation using different angles between adjacent states is given as an example.

```
ROHDE&SCHWARZ IQSIM MAPPING FILE
special 8-PSK with mapping point compression
PSK
0
8
 0.866,        0.5
 0.5,          0.866
-0.5,          0.866
-0.866,        0.5
-0.866,       -0.5
-0.5,         -0.866
 0.5,         -0.866
 0.866,       -0.5
```



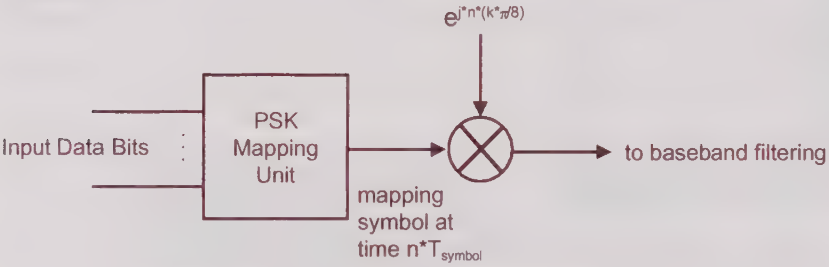
5.8.2 Modulation Parameters

Other parameters can also be configured depending on the selected modulation type.

Reference level: This parameter can only be defined for PSK and QAM modulation. In all other cases it is disabled (grey) or replaced by the FSK Index parameter (see below).

Under this item the maximum signal reference level used for PSK and QAM is defined. The reference level can be varied between -10 dB and 3 dB. Each I and Q value in the mapping table is compressed or expanded by a scale factor defined as $10^{\frac{\text{reference\_level}}{20}}$. This parameter can particularly be used for examining amplifier nonlinearities. See also section Amplifier Panel further down in this chapter.

PSK rotation: This parameter is only available with PSK modulation modes. Otherwise it is shown in shadowed mode. This parameter allows the mapping constellation for each symbol interval to be rotated by the selected phase. The rotation can be set in multiples of π/8 between 0 and 15. Rotation is in mathematically positive direction (anticlockwise). The following illustration shows the principle of PSK rotation:



n = symbol index n = 0, 1, 2, ..., sequence length -1

rotation = k*π/8, k = 0, 1, ..., 15

Fig. 5-20 Principle of PSK rotation

Example: *QPSK with an input bit sequence of {00, 01, 10, 11} is used in this example. With rotation switched off (k = 0), the following IQ output sequence is obtained after mapping (normalized to* $\sqrt{2}$*): {1 + j, -1 + j, -1 -j, 1 -j}. If a rotation of π/4 (k = 2) is selected, the following output sequence will be obtained* $\{(1+j)\,e^{j\cdot 0\cdot\pi/4}, (-1+j)\,e^{j\cdot 1\cdot\pi/4}, (-1-j)\,e^{j\cdot 2\cdot\pi/4}, (1-j)\,e^{j\cdot 3\cdot\pi/4}\}$*. This is exemplified in the illustration below.*

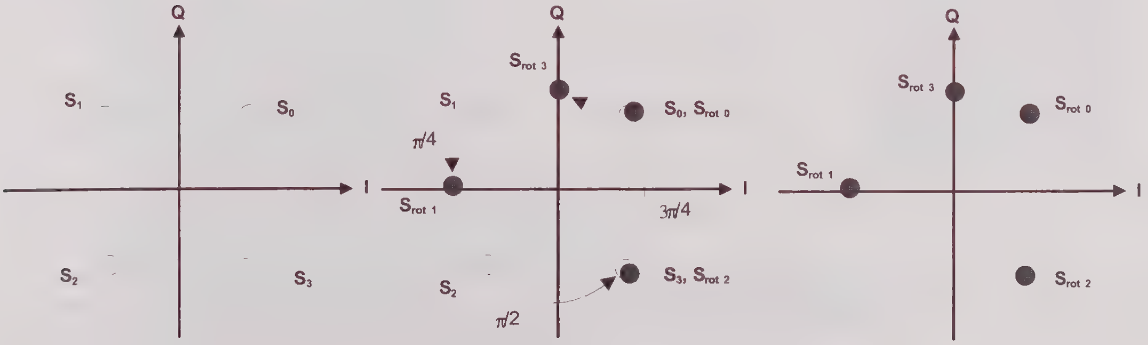


Fig. 5-21 Example of PSK rotation

FSK Index: This parameter can only be defined for 2FSK and 4FSK modulation. It is displayed instead of the reference level. With the FSK or modulation index, the frequency deviation for FSK can be increased or reduced. An index between 0.1 and 12 can be set. Sufficiently high oversampling has to be selected for the selected FSK index (see section Oversampling).

Alpha (non unif. QAM): This parameter can only be set for QAM modulations, in all other cases it is disabled (grey). The non-uniformity parameter Alpha comes from DVB (digital video broadcasting). The quadrants of the constellation diagram are pulled apart along the bisecting line. Consequently, the points of the constellation diagram are no longer uniformly distributed. If $\alpha = 1$ the mapping points in the constellation diagram are evenly distributed as usual; r_{min} is the minimum distance of a constellation point to its origin. The magnitude for the shift of quadrants in the constellation diagram is then defined as

$$\Delta r = (\alpha - 1) \cdot r_{min} .$$

The effect of parameter α on the constellation diagram is shown below.

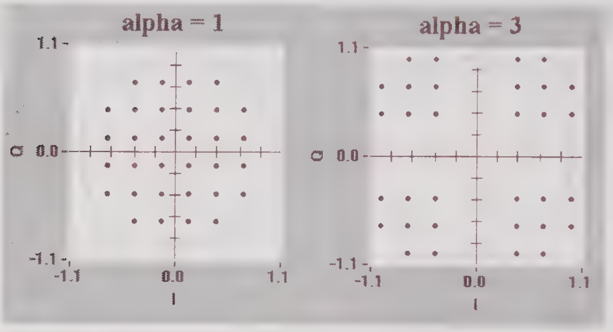


Fig. 5-22 Constellation diagram for 32QAM with Alpha = 1 and Alpha = 3

Alpha can be varied between 1 and 10.

GTFM b: This parameter can only be set with GTFM selected, otherwise it is disabled (grey). It can be set in the range from 0 and 1. The parameter is the ratio of the frequency deviation of the first bit period to the frequency deviation of the second period. With b = 0.5, the modulation indices of three consecutive bit periods are ¼, ½ and ¼ of the nominal modulation index 0.5.

5.8.3 Coding of Input Data

The binary data stream from the source can be recorded with the aid of a coder. The coding types supported by WinIQSIM do not contain redundancies. The number of coder input bits corresponds to the number of output bits. Block coding is mainly used to adapt the mapping schemes supported by WinIQSIM to the requirements of the respective communications standards. In most cases the coder only reorganizes the assignment of data symbols to the modulation states. WinIQSIM does not contain elements like channel coding or interleaving. These procedures can however be performed via the data source File (see section 5.6). WinIQSIM provides nine different coding types. They can be selected in the Coding field.

Only part of the available coding types is accessible for the different modulation modes. Coding types that cannot be selected are disabled (grey) in the selection menu. Conflicts may therefore occur between modulation type and coding when the modulation type is changed. If the selected coding is not permissible for the new modulation type, coding is automatically set to None. The matrix below gives permissible modulation/coding combinations.

Table 5-17 Permissible combinations of modulation and coding

Coding / Modulation	None	Gray	Diff.	Gray Diff.	GSM Diff.	NADC	TFTS	MSAT Diff.	Phase Diff.	Gray Diff. 8PSK
CW(none*)	-	-	-	-	-	-	-	-	-	-
Dirac Imp.	+	+	+	+	-	-	-	-	-	-
BPSK	+	+	+	+	+	-	-	-	-	-
QPSK	+	+	+	+	-	+	+	+	-	-
O-QPSK	+	+	+	+	-	+	+	+	-	-
π/4 DQPSK	+	+	+	+	-	+	+	+	-	-
8 PSK	+	+	+	+	-	-	-	-	-	+
8 PSK EDGE	+	+	+	+	-	-	-	-	-	-
16 QAM	+	+	+	+	-	-	-	-	+	-
32 QAM	+	+	+	+	-	-	-	-	+	-
64 QAM	+	+	+	+	-	-	-	-	+	-
256 QAM	+	+	+	+	-	-	-	-	+	-
MSK	+	+	+	+	+	-	-	-	-	-
2 FSK	+	+	+	+	+	-	-	-	-	-
4 FSK	+	+	+	+	-	+	+	+	-	-
GTFM	+	+	+	+	+	-	-	-	-	-
User	+	+	+	+	-	-	-	-	-	-

***)none**: With this item selected, the input data are not coded.

Gray coding: With Gray coding, subsequent binary data symbols only differ by one bit. This also applies to the last and first data symbol. Assuming a known length of 1, a Gray code with the length L can be obtained by mirroring the code table and placing 0 in front of the previous symbols and 1 in front of the mirrored symbol. In the following this procedure is explained for L = 3.

Table 5-18 Gray coding generation scheme

Decimal	Binary	Gray		Decimal	Binary	Gray
0	00	00	leading **0** added	0	000	**0**00
1	01	01		1	001	**0**01
2	10	11		2	010	**0**11
3	11	10		3	011	**0**10
Mirror axis		10	leading **1** added	4	100	**1**10
		11		5	101	**1**11
		01		6	110	**1**01
		00		7	111	**1**00

Differential coding (Diff.): Differential coding uses a memory function. The value of the current output bit c_n depends on the current output bit c_{n-1} and on the previously sent input bit c_{n-1}. The current output bit c_n is the difference between d_n and c_{n-1}. If d_n and d_{n-1} are equal (difference = 0), $c_n = 0$; if d_n and c_{n-1} are not equal (a difference occurs), $c_n = 1$. This corresponds to an exclusive OR (EXOR) gating of d_n and c_{n-1}

$$c_n = d_n \oplus c_{n-1}$$

Table 5-19 Differential coding

Current input bit d_n	**Previous input bit c_{n-1}**	**Coder output bit c_n**
0	0	0
0	1	1
1	0	1
1	1	0

Gray differential coding (Gray Diff.): Gray differential coding is a combination of Gray coding and differential coding. The coder input bits are first Gray-coded and then differentially coded.

GSM differential coding (GSM Diff.): This coding is similar to differential coding. The difference is that with GSM differential coding $c_n = 1$ when input bits d_n and d_{n-1} are equal (difference = 0) and $c_n = 0$ when d_n and d_{n-1} are not equal. This is a negation of the EXOR link for d_n and d_{n-1}. This coding is also used by the digital mobile radio standard GSM (Global System for Mobile communications).

$$\mathbf{c_n = \overline{(d_n \oplus d_{n-1})}}$$

Table 5-20 GSM differential coding

Current input bit d_n	**Previous input bit d_{n-1}**	**Coder output bit c_n**
0	0	1
0	1	0
1	0	0
1	1	1

NADC coding: NADC coding is only suitable for two-level modulation modes (ie modulation types with $2^2 = 4$ modulation states). The data symbol n consisting of input bits d_{2n} and d_{2n+1} is coded into an output symbol consisting of output bits c_{2n} and c_{2n+1} as shown in the table.

Table 5-21 NADC coding

Data symbol n (d_{2n} d_{2n+1})	Coder output symbol n (c_{2n} c_{2n+1})
00	00
01	01
10	11
11	10

If this coding is used with π/4 DQPSK, the data symbols are transmitted in the form of phase changes as specified by the NADC (North American Digital Cellular) standard .

TFTS coding: Same as NADC, TFTS coding can only be used for two-level modulation modes (ie modulation types with $2^2 = 4$ modulation states). The data symbol n consisting of input bits d_{2n} and d_{2n+1} is coded into a coder output symbol consisting of output bits c_{2n} and c_{2n+1} as shown in the table.

Table 5-22 TFTS coding

Data symbol n (d_{2n} d_{2n+1})	Coder output symbol n (c_{2n} c_{2n+1})
00	10
01	01
10	11
11	00

If this coding is used with π/4 DQPSK, the data symbols are transmitted as phase changes as specified by the TFTS (Terrestrial Flight Telephone System) standard.

MSAT differential coding (MSAT Diff.): Differential coding according to MSAT (Mobile Satellite) standard is selected with this option. Refer to the standard specifications for further information. The serial data stream from the source is first converted into a 2-bit parallel format (A,B). Starting from bit 1 of the input stream, all even-numbered bits form sequence A and all odd-numbered bits form sequence B. An input pair A(n), B(n) at time n is differentially coded into I(n) and Q(n) based on the values of the input pair A(n), B(n) and the previous pair I(n-1), Q(n-1). Coding is performed as follows:

$$I(n) = \overline{A(n) \oplus B(n)} \bullet (A(n) \oplus I(n-1)) + (A(n) \oplus B(n)) \bullet (B(n) \oplus Q(n-1))$$

$$Q(n) = \overline{A(n) \oplus B(n)} \bullet (B(n) \oplus Q(n-1)) + (A(n) \oplus B(n)) \bullet (A(n) \oplus I(n-1))$$

In a next step the pairs I(n), Q(n) are coded according to the following table.

Table 5-23 MSAT differential coding

I(n)	Q(n)	Coder output symbol n (c_{2n} c_{2n+1})
0	0	10
0	1	01
1	0	11
1	1	00

If this coding is used with π/4 DQPSK, the data symbols are transmitted as phase changes according to the MSAT standard.

Phase differential coding (Phase Diff.): Phase differential coding is used for DVB (digital video broadcasting) signals using 16, 32, 64 and 256QAM modulation. The MSBs (most significant bits) of the modulation data are differentially coded in order to obtain a π/2 rotation-invariant QAM constellation. Refer to the DVB standard for further information. The encoding scheme is as follows:

$$I(n) = \overline{A(n) \oplus B(n)} \bullet (A(n) \oplus I(n-1)) + (A(n) \oplus B(n)) \bullet (A(n) \oplus Q(n-1))$$

$$Q(n) = \overline{A(n) \oplus B(n)} \bullet (B(n) \oplus Q(n-1)) + (A(n) \oplus B(n)) \bullet (B(n) \oplus I(n-1))$$

Gray differential coding for 8PSK (Gray Diff. 8PSK): This coding is used by the VHF DIGITAL LINK (VDL) digital standard and is available only if 8PSK modulation is active. With this coding, the 3 bit data symbols of 8PSK are converted into phase steps as shown by the table below.

X_k	Y_k	Z_k	$\Delta\phi_k$
0	0	0	0 π / 4
0	0	1	1 π / 4
0	1	1	2 π / 4
0	1	0	3 π / 4
1	1	0	4 π / 4
1	1	1	5 π / 4
1	0	1	6 π / 4
1	0	0	7 π / 4

5.8.4 Symbol Rate and Sequence Length

Symbol rate and sequence length can also be set in the Modulation window of the panel.

Symbol rate: The symbol rate must be adjusted so that a correct clock rate can be set for the I/Q source AMIQ. Setting is performed in the **Symbol Rate** field. The symbol rate is obtained by dividing the bit rate by the modulation level. The modulation level corresponds to the number of bits in the input stream from the data source transmitted in one symbol. NADC uses π/4 DQPSK modulation, for instance. With this modulation 2 bits per symbol are transmitted. NADC uses a bit rate of 48.6 kbit/s. This yields a symbol rate of 48.6 kbit/s / 2 = 24.3 Ksymbols/s.

The symbol rate can be varied between 10 symbols/s and 100 Msymbols/s. The maximum symbol rate depends on oversampling and on the maximum clock rate of the I/Q source (AMIQ 100 MHz). The symbol rate is therefore defined as

$$\text{symbol rate}_{max} = 100\ \text{MHz} / \text{oversampling}.$$

The following table gives an overview of bit and symbol rates used in modern communication systems.

Table 5-24 Bit and symbol rates of modern communication systems

System	Bit rate / kbit/s	Symbol rate / Ksymbols/s
GSM	270.833	270.833
DECT	1152	1152
NADC	48.6	24.3
PDC	42	21
TFTS	44.2	22.1
PHS	384.0	192.0
TETRA	35.0	17.5

Sequence length: The sequence length specifies the length in data symbols of the I/Q signal to be calculated. A length between 1 and 4.000.000 (4M) can be set in the **Sequence Length** field. A memory of max. 4 Msamples is available in the output RAM of AMIQ for each of the I and Q signals. This value must not be exceeded. In the single-carrier mode, the number of sampling values is the product of sequence length and oversampling. The max. sequence length is therefore defined as

$$\text{sequence length}_{max} = 4.000.000 / \text{oversampling}.$$

In the multicarrier mode the number of sampling values is defined as

$$Sampling \cdot values = \frac{Oversampling * sequencelength}{Sampling \cdot rate}$$

5.8.5 Baseband Filtering and Filter Parameters

This section describes the selection of the baseband filter and of associated filter parameters. All baseband filters offered by WinIQSIM are lowpass filters. The various communication systems use different bandpass filters. The most frequently used filter types can be selected here. To be able to use other filters, a user-specific filter can be defined with the aid of a file. More details are given further down.

The baseband filter and modulation play a decisive role in signal shaping in the frequency and time domain. We therefore talk about baseband pulse shaping in addition to baseband filtering. The filter shapes the transmitted pulse in the baseband.

The output sequence of modulation mapping is a complex pulse sequence that is applied to the baseband filter. Depending on the chosen modulation and the bandpass pulse (see under **Baseband Impulse** further down) the pulses have a different width. The filter output signal is obtained by a convolution of filter impulse response and complex modulation pulse sequence.

The filters selectable in the **Filter Function** field are now described.

None: If None is selected no baseband filtering is performed. The pulse sequence is passed on to the modulator without modification.

Note: *A combination of None (with Dirac pulse) and PSK or QAM modulation should be avoided as it may cause unpredictable effects.*

Rectangular filter (Rect): The rectangular filter gives baseband pulses a rectangular shape with a pulse width of one symbol period T_{sym}. The filter response shows a sin(f) / f behaviour. The rectangular filter should be used for PSK and QAM modulation modes which do not require specific filter characteristic. The combination of the rectangular filter with FSK will result in a quadratic phase characteristic. The impulse response and the response of the rectangular filter are as follows:

$$H(f) = \mathrm{si}\left(f \cdot T\right)$$

$$h(t) = 1 \quad \text{for} \quad 0 \le t < T$$

$$h(t) = 0 \quad \text{for} \quad t \ge T$$

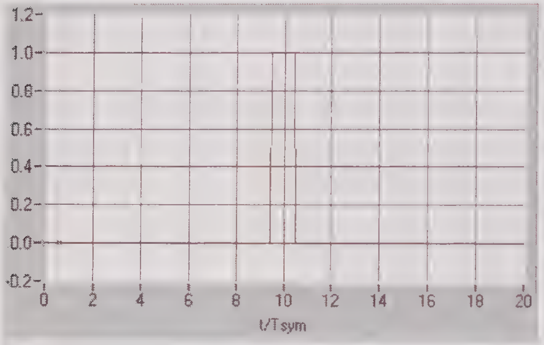


Fig. 5-23 Impulse response h(t) of rectangular filter (impulse length 20)

Square Root Raised Cosine Filter (Root Cosine): The response of the square root cosine filter is described by

$$H(f) = \begin{cases} 1 & \text{for} \quad 0 < f < \dfrac{(1-\alpha)}{2T} \\ \sqrt{\dfrac{1}{2}\left(1 - \sin\left(\pi \dfrac{(2fT-1)}{2\alpha}\right)\right)} & \text{for} \quad \dfrac{(1-\alpha)}{2T} \le f \le \dfrac{(1+\alpha)}{2T} \\ 0 & \text{for} \quad f > \dfrac{(1+\alpha)}{2T} \end{cases}$$

This equation can also be written as

$$H(f) = \begin{cases} 1 & \text{for} \quad 0 < f < \dfrac{(1-\alpha)}{2T} \\ \cos\left(\dfrac{\pi T}{2\alpha}\left(f - \dfrac{(1-\alpha)}{2T}\right)\right) & \text{for} \quad \dfrac{(1-\alpha)}{2T} \le f \le \dfrac{(1+\alpha)}{2T} \\ 0 & \text{for} \quad f > \dfrac{(1+\alpha)}{2T} \end{cases}$$

where T is the symbol period. Parameter α is the **roll-off factor.** It determines the steepness of the filter edges in the time domain and the transition bandwidth in the frequency domain. With WinIQSIM, a roll-off factor between 0.01 and 0.99 can be selected in the **Roll Off** field below the Filter function field. The roll-off field is displayed in turn with the filter parameters entry field of other filter types. The impulse response of the filter is

$$h(t) = \frac{\sin\left(\pi(1-\alpha)\,{}^{t}\!/_{T}\right) + 4\alpha\,{}^{t}\!/_{T}\cos\left(\pi(1+\alpha)\,{}^{t}\!/_{T}\right)}{\pi\,{}^{t}\!/_{T}\left(1-\left(4\alpha\,{}^{t}\!/_{T}\right)^{2}\right)}$$

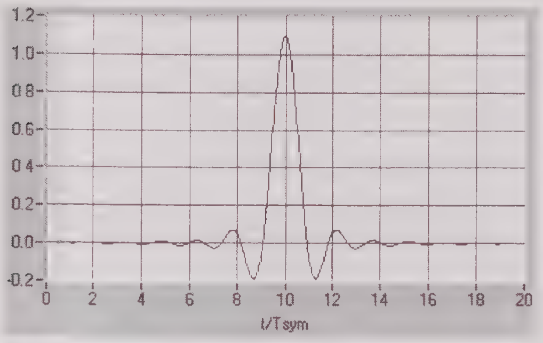


Fig. 5-24 Impulse response h(t) of square root raised cosine filter (α = 0.35, impulse length 20)

Cosine filter (Cosine): This filter is similar to the square root raised cosine filter. The frequency response of the cosine filter is described by

$$H(f) = \begin{cases} 1 & \text{for} \quad 0 < f < \frac{(1-\alpha)}{2T} \\ \cos^2\left(\frac{\pi T}{2\alpha}\left(f - \frac{(1-\alpha)}{2T}\right)\right) & \text{for} \quad \frac{(1-\alpha)}{2T} \leq f \leq \frac{(1+\alpha)}{2T} \\ 0 & \text{for} \quad f > \frac{(1+\alpha)}{2T} \end{cases}$$

where T is again the symbol period and α the **roll-off factor.** The roll-off factor determines the edge steepness of the filter in the time domain and the transition bandwidth in the frequency domain. With WinIQSIM, a roll-off factor between 0.01 and 0.99 can be selected in the **Roll Off** field below the Filter Function field. The roll-off field is displayed in turn with the parameter entry field of other filter types. The impulse response of the filter is

$$h(t) = \frac{\sin(\pi \, t/T) \, \cos(\pi\alpha \, t/T)}{\pi \, t/T \, (1 - 4(\alpha \, t/T)^2)}$$

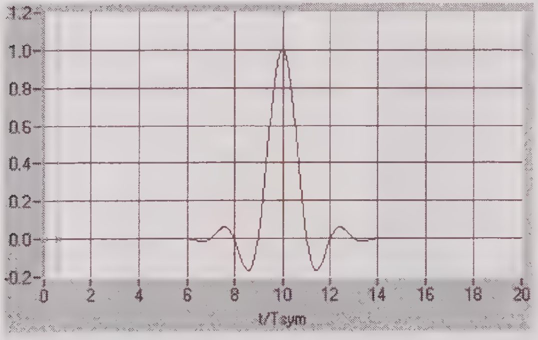


Fig. 5-25 Impulse response h(t) of cosine filter (α = 0.35, impulse length 20)

Gaussian filter (Gauss): When using the Gaussian filter, the frequency response of the filter has the shape of a Gaussian bell. The filter characteristic can be expressed by the normalized bandwidth B * T, where B is the 3 dB bandwidth of the filter and T the duration of a symbol period. The normalized bandwidth B * T can be selected in the range from 0.1 to 10 with 0.01 resolution in the **B * T** field in the Filter window. This field is displayed alternately with the roll-off factor field.
The frequency response of the Gaussian filter is described by

$$H(f) = \exp\left(-0.3466\left(\frac{f}{B\,T\,f_{bit}}\right)^2\right)$$

The impulse response of this filter is also a Gaussian characteristic with the shape

$$h(t) = \frac{1}{\sqrt{2\pi}\sigma T}\cdot\exp(-t^2/(2\sigma^2T^2)) \qquad \text{with } \sigma=\frac{\sqrt{\ln(2)}}{2\pi BT}$$

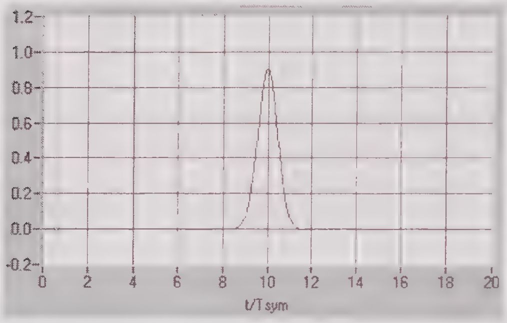


Fig. 5-26 Impulse response h(t) of Gaussian filter (BT = 0.3, impulse length 20)

Gaussian EDGE Filter (Gauss EDGE): When using the Gaussian EDGE filter the filter function assumes the shape of a linearized Gaussian bell. The time-bandwidth product of this filter cannot be changed. The coefficients of this filter were suggested by ETSI for the extension of GSM (GSM EDGE: Enhanced Data Rates for GSM Evolution).

Partial Response Filter (PRS): The frequency response of the PRS filter is described by

$$H(f) = \cos(\pi f T) \qquad f < 1/(2T)$$

$$h(t) = \frac{1}{2}si\left(\frac{t}{T}-\frac{1}{2}\right)+\frac{1}{2}si\left(\frac{t}{T}+\frac{1}{2}\right) \qquad \text{with } si(x)=\frac{\sin(\pi x)}{\pi x}$$

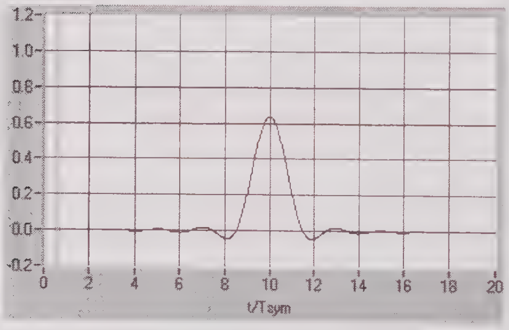


Fig. 5-27 Impulse response h(t) of partial response filter (impulse length 20)

When using the PRS filter with QPSK, 16QAM and 64QAM, the modulation types 9QPRS, 49QPRS and 225QPRS can be generated.

CDMA2000 1X: A special baseband filter for the 1X mode and 3X multicarrier mode is defined in tabulated form in the CDMA2000 (IS2000) standard.

This filter is implemented in WinIQSIM under the designation CMDA2000 1X Filter.

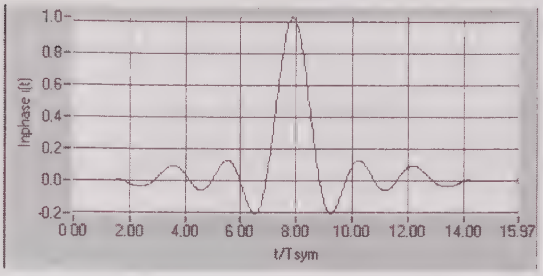


Fig. 5-28 Impulse response h(t) of CDMA2000 1X filter

CDMA2000 3X DS: A special baseband filter for the 3X direct spread mode is defined in tabulated form in the CDMA2000 (IS2000) standard. This filter is implemented in WinIQSIM under the designation CDMA2000 3X DS Filter.

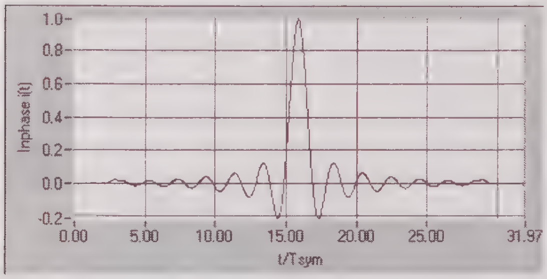


Fig. 5-29 Impulse response h(t) of CDMA2000 3X DS filter

Ideal Low Pass: With this filter, the frequency response of an ideal low pass filter with a cutoff frequency of half the symbol rate is obtained. This filter type is recommended if subsequent oversampling of the signal from an import system is to be carried out. To ensure good signal quality, a large impulse length (128) is recommended for this filter.

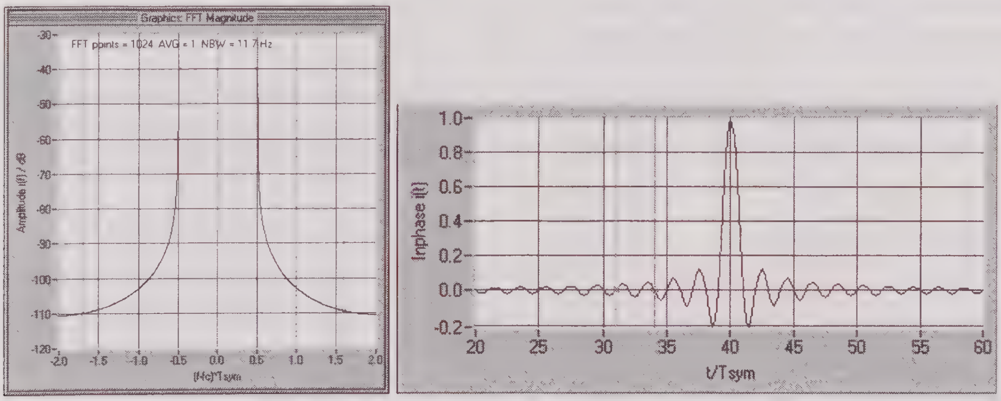


Fig. 5-30 Frequency response and impulse response h(t) of ideal low pass filter

Butterworth Filter: In WinIQSIM, 3rd-, 5th- and 7th-order Butterworth filters are implemented. Apart from the filter order, the cutoff frequency can be selected as a function of the symbol rate. The cutoff frequency is selectable from 0.1 to 2.0 of the symbol rate. The diagrams below show the frequency response and the impulse response of a 7th-order Butterworth filter at different cutoff frequencies.

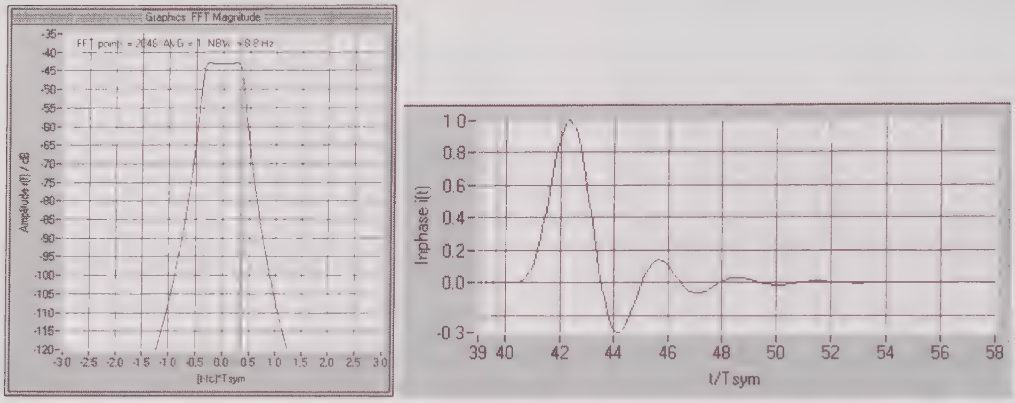


Fig. 5-31 Frequency response and impulse response h(t) of 7th-order Butterworth filter with cutoff frequency 0.7 * symbol rate

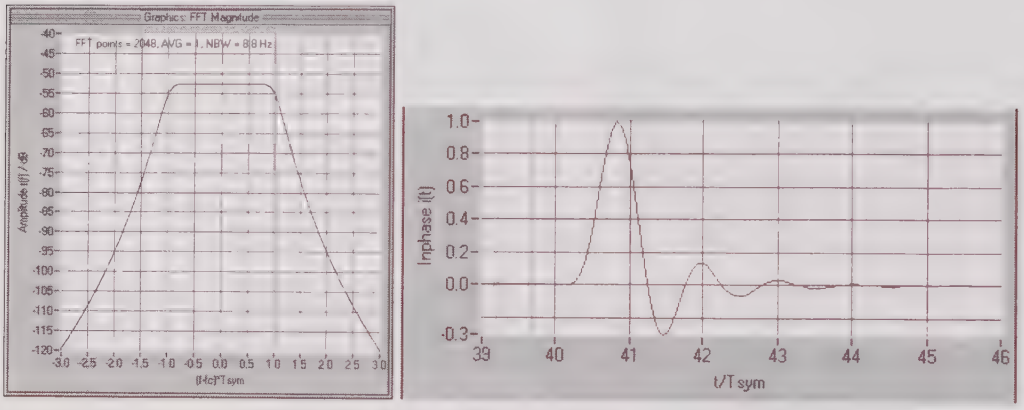


Fig. 5-32 Frequency response and impulse response h(t) of 7th-order Butterworth filter with cutoff frequency 2.0 * symbol rate

User filter: To allow the user to load filter types that are not predefined by WinIQSIM, a user-specific filter can be configured in a data file. Selecting the User Filter function opens a window where a file with the extension ***.IFL** (IQSIM filter file) can be selected. The user filer file must be an ASCII file with the following format.

Table 5-25 Format of user filter file

Line	Content
1	ROHDE&SCHWARZ IQSIM FILTER FILE
2	Comment line with any entries
3	Pulse length of filter as multiples of the symbol period
4	Oversampling
5	Filter coefficient No. 1 for I (filter coefficient No. 1 for Q)
6	Filter coefficient No. 2 for I (filter coefficient No. 2 for Q)
7	Filter coefficient No. 3 for I (filter coefficient No. 3 for Q)
8	etc. for all filter coefficients

The first data line gives the name ROHDE&SCHWARZ IQSIM FILTER FILE for file identification. Line 1 may be preceded by an arbitrary number of comment lines which have to begin with a # sign. These lines are followed by a compulsory comment line (without #). Subsequently, the pulse length (see under

Impulse Length further down) and the oversampling factor (see under **Oversampling** further down) have to be specified for the file-defined filter.

The filter coefficients are to be specified in the following lines. The quadrature signal and the in-phase signal can be assigned a different filter characteristic. In each line the coefficient for I must be specified first and then, separated by a comma, the coefficient for Q. If the filter characteristic of I and Q is identical, only one coefficient need be specified which will then be used for both. By entering two coefficients a skew between the I and Q channel can be simulated.

The number of lines required for entering coefficients is obtained from the product of oversampling factor and pulse length plus 1. Number of coefficients = pulse length * oversampling factor + 1, eg if a pulse length of 8 is selected and the oversampling factor is 16, 8 * 16 + 1 = 129 (pairs of) coefficients have to be entered. Filter files with up to 4.096 (max. pulse length 28, max. oversampling 32) pairs of coefficients may be used.
The gain of the user filter will be

$$\frac{a}{\mathrm{dB}} = 10 \cdot \log\left[\frac{\sum(\mathrm{coeff.I})^2 + \sum(\mathrm{coeff.Q})^2}{\mathrm{oversampling}}\right]$$

To avoid additional signal amplification, the gain of the user filter should be 0 dB.
To ensure optimum performance, the filter coefficients should be calculated with the same oversampling factor as for signal generation. Interpolation between the filter coefficients will be made if the oversampling factor in the filter file is different from that selected in the program.

As an example the filter file of a 10th order Bessel filter with a cut-off frequency of 3.9 kHz is given here:

```
ROHDE&SCHWARZ IQSIM FILTER FILE
Bessel 3.9kHz
2
8
 0.5E-10
-6.9707418737E-10
 8.5601508927E-04
 7.2487204323E-02
 3.5448989297E-01
 4.1754619830E-01
 1.5030495697E-01
 4.0879660975E-03
-1.6577696971E-04
 8.2517762928E-04
-5.8935568413E-04
 2.0248346559E-04
 2.6200266535E-06
-4.2197053913E-05
 2.2462756404E-05
-4.0753034935E-06
-1.9596102325E-06
```

5.8.6 Sin (x)/x Compensation

When the modulation pulse sequence passing through the baseband filter consists of rectangular pulses (see **Baseband Impulse** further down), the signal shows an additional frequency response according to the function si(f) = sin(f) / f. By activating the **Si Comp.** function by a click on the check box **On** next the **Si Comp.** field, this frequency response can be compensated for. The figure below shows the sin (f)/f function in the magnitude spectrum.

Note: *The Si distortion should not be mistaken for the distortion generated by the D/A converters in AMIQ, which the user can select to be automatically corrected by WinIQSIM when IQ sequences are transferred into AMIQ.*

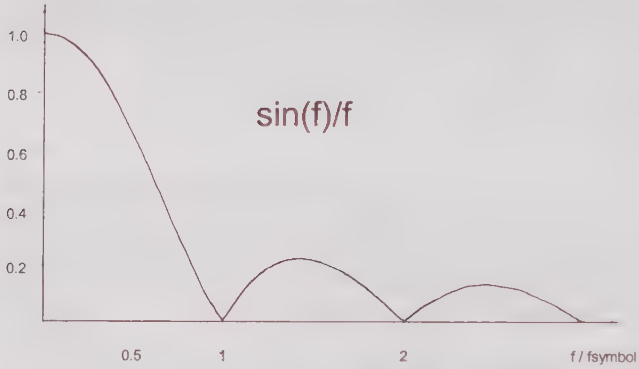


Fig. 5-33 Sin (f)/f function in the magnitude spectrum

A compensation bandwidth normalized to the symbol rate can be entered in the range from 0 to 0.95 in the **Si Comp. BW** field. This normalized bandwidth should suit the selected modulation and filter type. The entered value should be larger than the filtering bandwidth.
The compensation bandwidth can be adjusted so that even incomplete compensation can be simulated.

Example: Cosine filter with roll-off factor $\alpha = 0.2$
The signal bandwidth is approx. $(1 + \alpha) * f_{sym} / 2$, that is $(1 + 0.2) / 2 = 0.6$ when normalized to the symbol rate. A compensation bandwidth greater than 0.6 should therefore be set.

5.8.7 Window Function and Window Parameters

The impulse response of a filter to a data symbol is spread over several symbol periods. The number of symbol periods over which the impulse response of the filter is considered in the calculation of the I and Q values is determined by the **Impulse Length** parameter. The **Window Function** is an additional filter that can be placed over the impulse response for a period determined by the impulse length. This window function is simply an additional weighting factor for the coefficients of the baseband filters. It should be used with filters with a slowly decreasing impulse response (eg cosine filter) in order to reduce adjacent-channel interference.

In WinIQSIM five window functions can be selected which are now described together with their window parameters. The function can be selected in the **Window Function** field. The entry field for the window parameter is located directly below.

Rectangular window (Rect): The rectangular window function truncates the impulse response of the baseband filter outside the window. The impulse response inside the window remains unchanged. Truncating the impulse response by the rectangular window may possibly influence the adjacent-channel interference. The rectangular filter should therefore be used with intersymbol-interference-free filters and with an even oversampling factor. In this case the impulse response is truncated at a zero crossing. The window can also be used in combination with a Gaussian filter. This combination is used by GSM for instance.

Hanning window (Hanning): The Hanning function forces the impulse response at the boundaries of the window to zero, thus avoiding truncation errors. However, this filter type introduces amplitude distortion. The Hanning filter is described by

$$w(i) = 0.5\left[1+\cos\left(2\pi \, {}^{i}\!/_{k}\right)\right] \qquad -\frac{k}{2} \le i \le \frac{k}{2}$$

$$= 0 \qquad \textit{otherwise}$$

where k = pulse length · oversampling.

Kaiser window (Kaiser): The Kaiser window is a compromise between the rectangular and the Hanning filter. The behaviour of the Kaiser filter is influenced by the **Kaiser parameter** β. β can be set in the range from 1 to 10 in steps of 0.1 directly below the selection window. A Kaiser filter with $\beta = 0$ is equal to the rectangular filter. For NADC modulation β should be 2.7 .
The filter is described by

$$W(i) = \frac{I_0\left(\beta\sqrt{1-\left(\frac{2i}{k}\right)^2}\right)}{I_0(\beta)} \qquad -\frac{k}{2} \le i \le \frac{k}{2}$$

$$= 0 \qquad \textit{otherwise}$$

where I_0 is the Bessel function.

Hamming window (Hamming): A Hamming function is used to window the filter response. The Hamming window is similar to the Hanning window.
The Hamming window is described by

$$W(i) = 0.54 - 0.46 \cdot \cos(2\pi \frac{i}{k}) \qquad -\frac{k}{2} \le i \le \frac{k}{2}$$

$$= 0 \qquad \textit{otherwise}$$

Chebyshev window (Chebyshev): A Chebyshev function is used to window the filter response. The behaviour of the Chebyshev window shows a minimum width of the passband at a given ripple of the stopband. The ripple of the stopband can be set in 0.1 dB steps in the range from 10 to 80 dB in the **Chebyshev Ripple** field directly below the Window Function field.

5.8.8 Impulse Length, Oversampling and Baseband Pulse

Here the remaining parameters of the Modulation Settings panel are described.

Pulse length: As already pointed out, the pulse length determines the number of symbol periods over which the filter impulse response is considered in the I/Q calculation. The pulse length has a considerable effect on the modulation accuracy. With GSM, a pulse length of 5 bits or greater is required. In order to obtain highly accurate signals, a great pulse length (>20) should be selected. In particular if a root cosine filter is used for baseband filtering, too small a pulse length would highly affect the error vector magnitude of the I/Q signal. The pulse length can be set between 1 and 128 symbol periods in the **Impulse Length** field.

Oversampling: Oversampling defines the number of samples to be calculated for each symbol. This factor helps to increase the frequency offset of the aliasing products produced by D/A conversion of the signal. As a result simpler methods can be used for filtering out the aliasing products. On the other hand, oversampling increases the number of samples to be calculated and transferred to the I/Q signal source. With increasing oversampling, the signal length is limited by the memory depth of the signal source, which reduces the number of input data that can be transmitted (see also **Sequence Length).** A good compromise for the oversampling factor are values between 4 and 12. Oversampling can be set between 1 and 32.

To simplify the selection of an optimum oversampling factor, oversampling can be set automatically. In this case **Auto** has to be selected in the box next to the Oversampling field. The Oversampling field is disabled (grey) and the automatically set value is displayed. This is of particular interest with FSK modulation where, depending on the FSK index, a sufficiently high oversampling factor has to be selected to avoid truncation of the signal spectrum.

Baseband pulse: In this field the baseband pulse for filter excitation can be selected. A Dirac pulse, a rectangular pulse or Auto can be selected. The impulse function depends on the signal type to be generated. Information on the pulse type is given in the specifications of the respective telecommunication system standards.

In the **Auto** mode, the Dirac pulse is used for all PSK and QAM modulations and the rectangular pulse for FSK modulation types.

5.8.9 Display of Constellation Diagram

The **Advanced** key is provided at the bottom right of the Modulation Settings panel. With this button the display of the advanced section of the panel can be switched on or off.

In this section the current modulation mapping is graphically displayed in a constellation diagram. Modulation mapping for PSK and QAM modulations is displayed in the form of a constellation diagram, for FSK as a frequency deviation.

In these diagrams the effect of a modulation parameter can be observed. For instance, if the FSK index is increased for 4FSK, the frequency shift increases as well. This display is also very helpful in the case of user modulation because the modulation data read from the file can be checked.

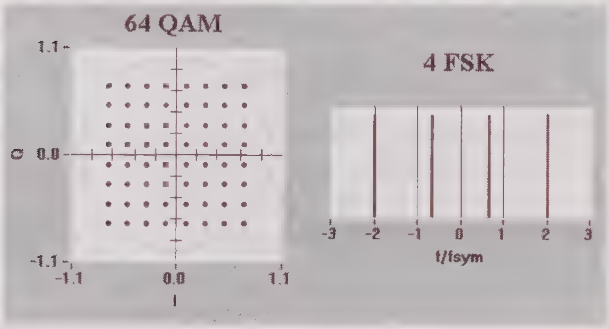
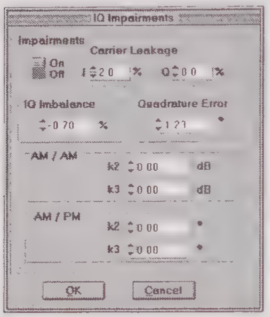


Fig. 5-34 Constellation diagram in the Modulation panel

5.9 I/Q Impairments Panel

In this panel impairments of the I/Q modulator can be configured. Linear impairments such as carrier leakage, I/Q imbalance and quadrature error and non-linear effects like AM/AM and AM/PM conversion can be simulated. All impairment types defined in the panel can be enabled and disabled by means of a switch in the top left-hand corner of the panel. The parameter fields in the panel can be edited irrespective of the switch position. However, settings made in the panel have no effect on signal generation when the switch is in the position Off.



Carrier Leakage: I 2.0 %, Q 0.0 %

IQ Imbalance: -0.70 %

Quadrature Error: 1.21 °

AM / AM: k2 0.00 dB, k3 0.00 dB

AM / PM: k2 0.00 °, k3 0.00 °

Fig. 5-35 I/Q Impairments panel

The individual impairments are now described.

Carrier Leakage: The carrier leakage for the I and Q modulator signal can be set here. The carrier leakage of the I and Q signals can be varied between -50% and +50%. A carrier leakage of 0% will theoretically lead to the optimum carrier suppression. All I signals are shifted by a fixed value depending on the value selected for carrier leakage I. There is the same dependence of Q values on the carrier leakage Q parameter. The effect is illustrated by the diagram below.

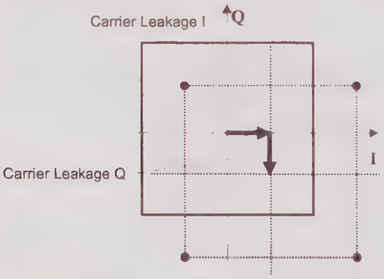


Fig. 5-36 Effect of carrier leakage

IQ Imbalance: For an ideal I/Q modulator, the gain in the I and Q signal paths is identical. A difference in gain between the two signal components is expressed in terms of I/Q imbalance. Using the I/Q imbalance parameter, the length of the I vector can be changed with respect to the Q vector. Positive values indicate that the gain of the I vector is higher by the respective percentage than that of to Q vector and vice versa. In WinIQSIM the imbalance can be set in the range from -30% to +30%. This effect is shown in the following diagram.

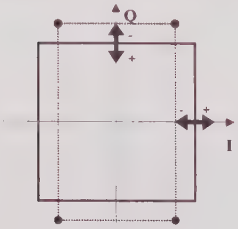


Fig. 5-37 Effect of I/Q imbalance

Quadrature Error: The phase angle between the I and Q signals is 90° in the ideal case. Deviations from this angle are expressed in terms of a quadrature error. This means that in an ideal I/Q modulator with a phase angle of 90° the quadrature offset is 0°. A positive quadrature offset will result in phase angles greater than 90°, negative values in angles less than 90°. This parameter can be set in the range -30% to +30%. The effect of the quadrature error is illustrated by the diagram below.

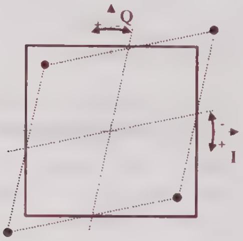


Fig. 5-38 Effect of quadrature error

AM/AM and AM/PM conversion: Nonlinearities of I/Q modulators can be described in many ways. Generally a modulated signal can be described as

$$s(t) = i(t) + j \cdot q(t)$$

where i(t) is the amplitude and Φ(t) the time-dependent phase function of the signal. A signal distorted by nonlinearities of the I/Q modulator can be described as

$$s'(t) = i'(t) + j \cdot q'(t)$$

with

$$\mathbf{a'(t) = a(t) + k_{2a} a(t)^2 + k_{3a} a(t)^3}$$

and

$$\phi'(t) = \phi(t) + k_{2\phi} a(t) + k_{3\phi} a(t)^2.$$

The amplitude errors of i and q are calculated as follows:

$\Delta i = k_{2a} \cdot i(t)^2 + k_{3a} \cdot i(t)^3$ and

$\Delta q = k_{2a} \cdot q(t)^2 + k_{3a} \cdot q(t)^3.$

The phase errors are calculated as follows:

$\Delta \varphi i = k_{2\varphi} \cdot i(t)^2 + k_{3\varphi} \cdot i(t)^3$ and

$\Delta \varphi q = k_{2\varphi} \cdot q(t)^2 + k_{3\varphi} \cdot q(t)^3.$

To allow also simulation of negative coefficients, the coefficients that can be entered in the panel are converted linearly as shown below and substituted in the above equations:

$$k_{2a} = 10^{\frac{k_{2a\_panel}}{20}} - 1 \text{ and } k_{3a} = 10^{\frac{k_{3a\_panel}}{20}} - 1.$$

The variation of the signal amplitude with respect to the original amplitude is called AM/AM conversion. It is described by a 3rd order polynomial in a(t). The polynomial coefficients of the square and the cubic components k_{2a} and k_{3a} can be set between -3 dB and +3 dB.

The variation of the phase with respect to the original amplitude is called AM/PM conversion. Due to nonlinearities, amplitude modulation (AM) also causes phase modulation (PM). This effect can be simulated as shown by the above formula. The conversion factors $k_{2\Phi}$ and $k_{3\Phi}$ can be varied in the range -30° to +30°.

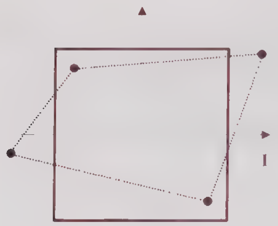
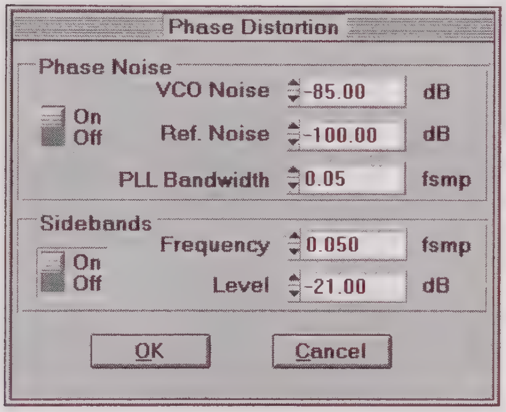


Fig. 5-39 Effect of AM/AM and AM/PM conversion factor

5.10 Phase Distortion Panel

In this panel the impairments caused by phase noise and spurious sidebands can be simulated. WinIQSIM assumes a standard phase-locked loop (PLL) consisting of a VCO (voltage-controlled oscillator) locked to a reference frequency by means of a frequency divider. The division factor m is assumed to be 1 in this model. If the division factor m of your system is greater than 1, the reference noise has to be increased by 20 log(m).

All frequencies entered in this panel are normalized to the baseband sampling rate f_{sample}. This rate is the product of the current symbol rate f_{symbol} and the oversampling factor.
The panel comprises two windows, Phase Noise and Sidebands. The noise components of the two windows can be switched on and off separately by means of the On/Off switched provided at the left-hand side of the windows. Each of the windows is represented by a block in the block diagram.



VCO Noise -85.00 dB
Ref. Noise -100.00 dB
PLL Bandwidth 0.05 fsmp
Frequency 0.050 fsmp
Level -21.00 dB

Fig. 5-40 Phase Distortion panel

5.10.1 Phase Noise

The phase noise can be configured with parameters VCO Noise, Reference Noise and PLL Bandwidth.
VCO Noise: The phase noise of the VCO measured at an offset frequency of f_{symbol} / 2 can be entered. It is assumed that the phase noise of the VCO decreases by 20 dB per decade of the frequency offset (6 dB per octave). The phase noise can be set in the range -140 dB to -60 dB.

Ref. Noise: Here the reference frequency phase noise of the PLL can be entered. It is assumed to be constant with the frequency. The parameter can be set between -140 dB and -60 dB.

PLL Bandwidth: The bandwidth of the PLL normalized to the baseband sampling rate can be set. The bandwidth can be selected in the interval 0 to 0.25 f_{sample}. When the PLL bandwidth is set to 0, a free-running VCO is simulated (no reference frequency).

Example for the entry of a normalized bandwidth:
f_{symbol} = 100 kHz, oversampling = 8, desired PLL bandwidth = 160 kHz
The baseband sampling rate is described by $f_{sample} = f_{symbol}$ * oversampling = 100 kHz * 8 = 800 kHz.
The value to be set in the panel for the normalized bandwidth is therefore
B_{PLL} / f_{sample} = 160 kHz / 800 kHz = 0.2.
The effects of the phase noise are shown in the figure below. It shows the constellation diagram of a QPSK-modulated signal with superimposed phase noise.

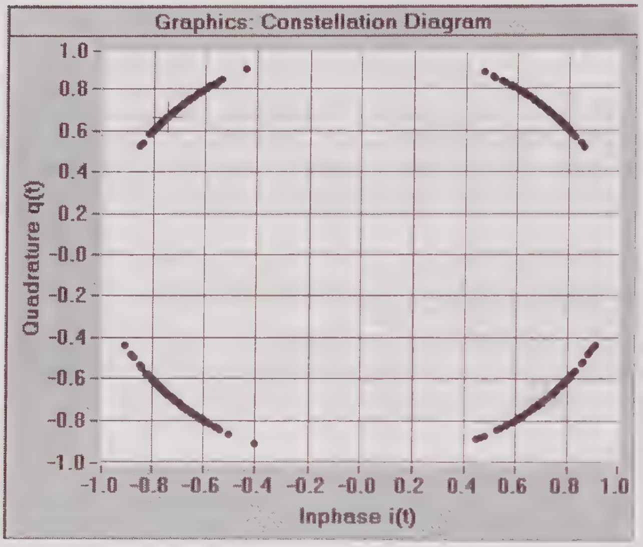


Fig. 5-41 Impairment of QPSK signal by phase noise

5.10.2 Sidebands

Discrete frequency sidebands mostly due to hum or imperfect reference frequency suppression can be simulated by switching on the sidebands function. The sidebands can be set by means of the frequency and level parameters.

Frequency: The frequency of the discrete sidebands normalized to the baseband sampling rate can be entered in the range -0.35 f_{sample} to +0.35 f_{sample}.

Level: With this parameter the level of the spurious sidebands can be entered as a function of the signal level. A value between -80 dB and -20 dB can be set.

The diagram below shows the magnitude spectrum of a QPSK signal with the sidebands parameter switched on. The discrete spectral lines at the right and left of the main lobe are clearly visible in the spectrum.

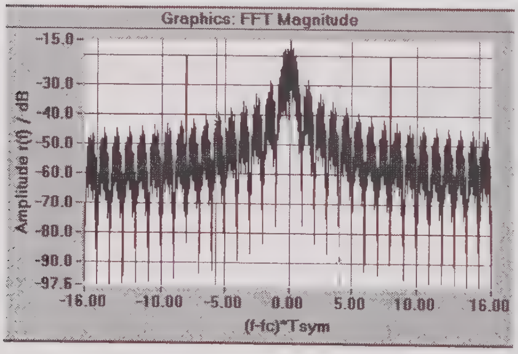
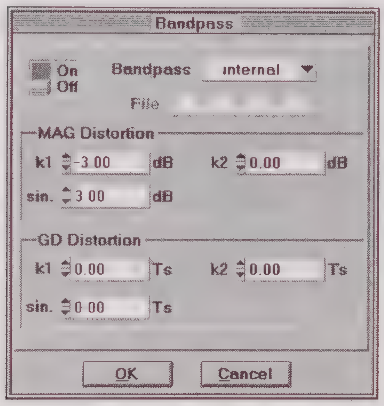


Fig. 5-42 Magnitude of a QPSK signal disturbed by sidebands

5.11 Bandpass Panel

The bandpass block simulates a bandpass filter at the RF. This allows for example the effect of an IF filter on the modulation signal to be tested. The bandpass in the RF range must be converted to an equivalent (complex) lowpass in the baseband using bandpass-lowpass transformation. This operation and the subsequent discrete convolution of I/Q signal and complex impulse response of the equivalent lowpass filter involve a considerable amount of computing. The bandpass block requires a longer computation time than any other function of the program.
In this panel it can be decided whether the internally defined bandpass or a user-defined bandpass should be used, and two groups of parameters are provided for the configuration of bandpass filter, magnitude (MAG) distortion and group-delay (GD) distortion.

The Bandpass block can be cut into or switched out of the signal path using the On/Off switch.



Bandpass internal

k1 -3.00 dB
k2 0.00 dB
sin. 3.00 dB

k1 0.00 Ts
k2 0.00 Ts
sin. 0.00 Ts

Fig. 5-43 Bandpass panel

Bandpass: In this field a selection can be made between an **internal** bandpass model or a **user** bandpass from a file. The internal bandpass model sets the functions r(f) for the signal amplitude characteristic and gd(f) for the group delay of the bandpass as described further below. The parameters described under MAG Distortion and GD Distortion are only effective with the internal bandpass model.

With User selected, a selection window is opened. In this window a bandpass file with the fixed extension ***.ibp** (IQSIM bandpass) can be loaded. The selected user file is displayed in the File field below the Bandpass selection field.

The format of a user bandpass file and a user baseband filter is the same (see section 5.8.5). The only difference is that the coefficients for I and Q have to be specified for the user bandpass.

The effects of the bandpass on the signal amplitude can be set in the **MAG Distortion** window. A distinction is made between linear ($\mathbf{k_1}$), square ($\mathbf{k_2}$), and sinusoidal (**sin.)** amplitude distortions.

$\mathbf{k_1}$: With this parameter a linear amplitude distortion can be set in the range -6 dB to 6 dB.

$\mathbf{k_2}$: With this parameter a square amplitude distortion can be set in the range -1.5 dB to 1.5 dB.

sin.: With this parameter a sinusoidal amplitude distortion can be set in the range 0 dB to 3 dB.
With n_p = number of periods of sinusoidal ripple in Nyquist bandwidths (in WinIQSIM $n_p = 4$) and a symbol duration $T = 1/f_{symbol}$ the amplitude of the bandpass filter as a function of frequency is described by:

$$\mathbf{r(f) = k_1 \cdot T \cdot f + k_2 (2T)^2 \cdot f^2 + \frac{k_{sin}}{2} \cdot \sin(2\pi \cdot f \cdot T \cdot n_p)}$$

In the **GD Distortion** window, the group-delay distortion caused by the bandpass can be set. A distinction is made between linear (**k_1**), square (**k_2**), and sinusoidal (**sin.**) distortions.

k_1: With this parameter a linear group-delay distortion can be set in the range -1 T to 1 T.

k_2: With this parameter a square group-delay distortion can be set in the range -0.5 T to 0.5 T.

sin.: With this parameter a sinusoidal group-delay distortion can be set in the range 0 to 0.5 T.
T is the symbol period. It is the reciprocal value of the symbol rate.
The group-delay characteristic versus frequency is described by:

$$gd(f) = k_1 \cdot T \cdot f + k_2 (2T)^2 \cdot f^2 + \frac{k_{sin}}{2} \cdot \sin(2\pi \cdot f \cdot T \cdot n_p)\,.$$

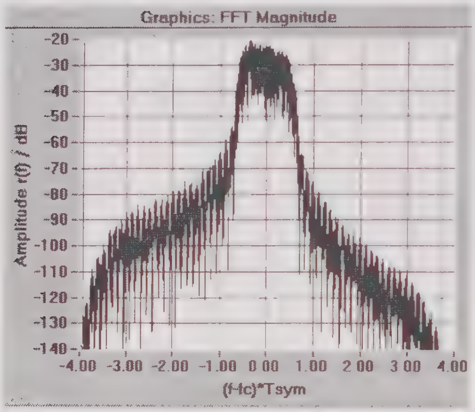
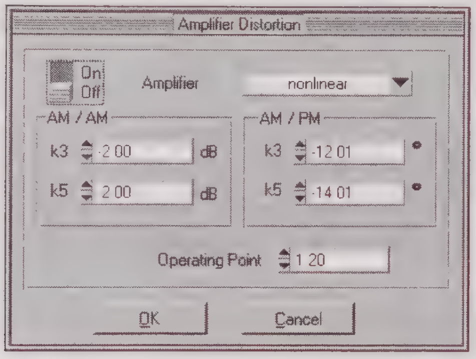


Fig. 5-44 Effect of bandpass on I/Q signal

5.12 Amplifier Panel

In this panel amplifier nonlinearities can be simulated. Three amplifier models are available. In addition to hard-limiting and soft-limiting amplifier model, a nonlinear amplifier can be selected. The On/Off switch at the top left of the panel enables or disables distortions caused by the amplifier. Since the amplifier distortions are simulated, a gain factor of one is assumed for all models. This means that in the ideal case the output voltage of the amplifier is identical to the input voltage.

The models can be selected in the Amplifier field. The parameters below are only relevant for the nonlinear model. For all other models the parameter entry fields are disabled. The amplifier models and their parameters are described in the following.



Amplifier: nonlinear

AM / AM
k3: -2 00 dB
k5: 2 00 dB

AM / PM
k3: -12 01 °
k5: -14 01 °

Operating Point: 1 20

Fig. 5-45 Amplifier panel

Soft-limiting and hard-limiting amplifiers: Some amplifiers show limiting effects. This means that the output voltage follows exactly the input voltage up to a certain value. Above this value the output voltage remains constant when the input voltage is further increased. When the **soft-limiting** amplifier is active, the ideal gain is limited to an amplifier input level of ±Limiting Level, which means that input values between -Limiting Level and + Limiting Level are ideally amplified. Input values below - Limiting Level are limited to - Limiting Level and those above +1 to +1.
The **hard-limiting** amplifier is a special model of the soft-limiting amplifier. The limit for the ideal gain is at an input level of 0. For all input values below 0 the output level is -1 and for all values above it is +1.
A characteristic of these two models is shown in the next drawing.
The limiting level at which limiting is to start in the case of the soft-limiting amplifier or up to which the level is to be amplified in the case of the hard and soft-limiting amplifier can be set in the Limiting Level field. The minimum value for the limiting level is 0.1.

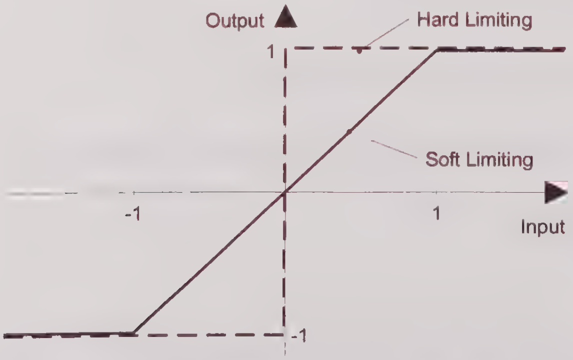


Fig. 5-46 Characteristic of soft-limiting and hard-limiting amplifiers

Soft-limiting and hard-limiting amplifiers only affect the amplitude of the output signal. The phase of the output signal remains unchanged.

Nonlinear amplifier: The input signal of a nonlinear amplifier can be described as follows:

$$s_{in}(t) = A_{in}(t)e^{j\phi_{in}(t)}$$

where $A_{in}(t)$ is the amplitude and $\Phi_{in}(t)$ the phase of the input signal.
The output signal of an amplifier is therefore

$$s_{out}(t) = A_{out}(t)e^{j\phi_{out}(t)}$$

where $A_{out}(t)$ is the amplitude and $\Phi_{out}(t)$ the phase of the output signal.

The field **Operating Point** permits to select the operating point of the nonlinear amplifier. The minimum value for the operating point is 0.1. All amplitudes of the input signal of this amplifier are normalized to the level of the operating point. The parameters for the amplitude A_{XXX} used in this section are already normalized to the operating point.

$$A_{norm} = \frac{A_{abs}}{Operating\_Point\_Level}$$

Example:
The impairment caused by an amplifier can be divided up into an inphase component (same phase as input vector) and an orthogonal component. This approach is illustrated by the following drawing.

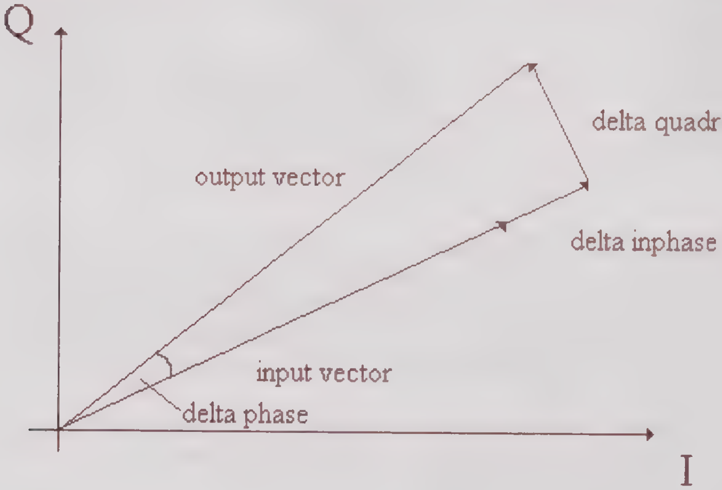


Fig. 5-47 Example of impairment caused by a nonlinear amplifier.

The following approach is used for the inphase impairment component:

$$\Delta inphase = k_{3a}A_{in}(t)^3 + k_{5a}A_{in}(t)^5$$

Thus, the following approach is obtained for the quadrature impairment component:

$$\Delta quadrature = k_{3\phi}A_{in}(t)^3 + k_{5\phi}A_{in}(t)^5$$

If these impairments are converted into an amplitude and a phase error, the following relationships are obtained:

$$\Delta A = \sqrt{(A(t) + \Delta inphase)^2 + \Delta quadrature^2} - A(t)$$

$$tan(\Delta\Phi) = \frac{\Delta quadrature}{A(t) + \Delta inphase}$$

For small impairments, these relationships can be simplified with the following approximations:

$(A(t) + \Delta inphase)^2 >> \Delta quadrature^2$, $A(t) + \Delta inphase \approx A(t)$, $tan(\Delta\Phi) = \Delta\Phi$

This results in:

$$\Delta A \approx \Delta inphase = k_{3a}A_{in}(t)^3 + k_{5a}A_{in}(t)^5$$

$$\Delta\Phi \approx \frac{\Delta quadrature}{A_{in}(t)} = \frac{k_{3\phi}A_{in}(t)^3 + k_{5\phi}A_{in}(t)^5}{A_{in}(t)} = k_{3\phi}A_{in}(t)^2 + k_{5\phi}A_{in}(t)^4$$

As a result, the relationship between input and output signal is as follows:

$$A_{out}(t) = A_{in}(t) + k_{3a}A_{in}(t)^3 + k_{5a}A_{in}(t)^5$$

$$\phi_{out}(t) = \phi_{in}(t) + k_{3\phi}A_{in}(t)^2 + k_{5\phi}A_{in}(t)^4$$

The parameters defining this relationship can be set in WinIQSIM.
AM/AM parameter: Parameters k_3 and k_5 describing the relationship between the output amplitude and the input amplitude can be set in the range -3 dB to +3 dB.
To be also able to simulate negative coefficients, the coefficients to be entered in the panel are linearized and inserted into the above equations as follows:

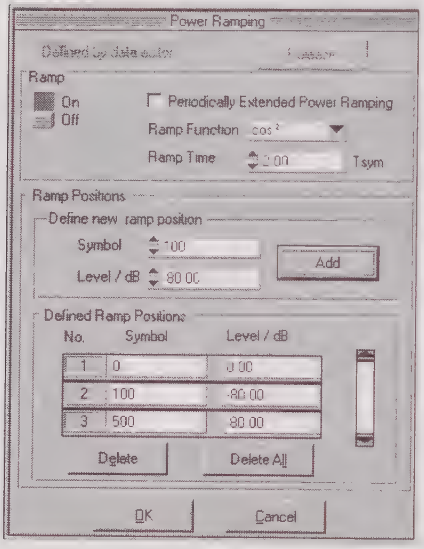
$$k_{3a} = 10^{\frac{k_{3a\_panel}}{20}} - 1 \text{ and } k_{5a} = 10^{\frac{k_{5a\_panel}}{20}} - 1 .$$

AM/PM parameter: Parameters k_3 and k_5 describing the relationship between the output phase and the input amplitude can be set in the range -30° to +30°.

Nonlinearities cause modulation errors and generate signal components outside the used channel.

5.13 Power Ramping Panel

Many modern communications standards prescribe power ramping for signal transmission. An example of such standards is TDMA (time domain multiple access). With this method only part of the transmitting time is available to the user. For the transmission he is assigned a time slot at regular intervals. In the time outside this time slot he cannot transmit. For this reason the transmitter power of the user must be switched on at the beginning of the slot and switched off again at the end. The switching ramps, which have a considerably effect on adjacent channels, are defined by many standards in terms of power time templates. The profile of power ramping can be determined in the Power Ramping panel.
In addition to the function and duration of a **ramp**, the position can also be determined at which the ramp should occur. Same as any other item in the block diagram following the modulation, power ramping can be switched on and off.



● On
○ Off

☐ Periodically Extended Power Ramping

Ramp Function: cos ²

Ramp Time: 2.00 Tsym

Symbol: 100

Level / dB: 80.00

No.	Symbol	Level / dB
1	0	0.00
2	100	-80.00
3	500	80.00

Fig. 5-48 Power Ramping panel

Ramp: In the Ramp window the type of ramp and its duration can be set. A selection can be made between a squared cosine function and a linear function. A ramp time between 0 and 16 T_{symbol} can be set in the **Ramp Time** field, normalized to the symbol period. Also fractions of the symbol period are available to the user.

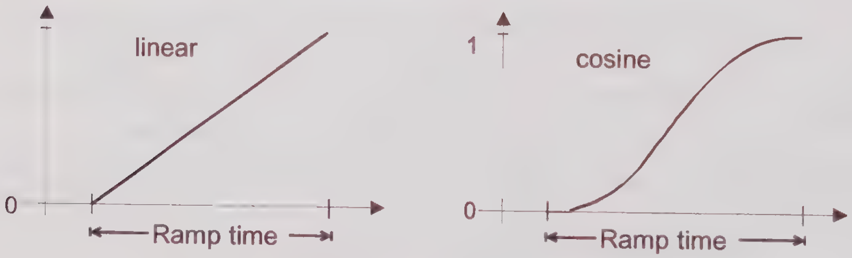


Fig. 5-49 Ramp functions of power ramping

Periodically Extended Power Ramping: In many applications, such as generating several frames of a GSM signal, power ramping is repeated periodically with each frame. To avoid the necessity of calculating and specifying the ramp positions of each generated frame, the **Periodically Extended Power Ramping** option is provided. If you activate this option, the time characteristic of the power ramping, as indicated in the panel, is continued periodically till the signal end.

Example: You want to generate ten frames of a GSM signal. In each frame, slot No. 1 should be activated. To achieve this, you first set the GSM modulation parameters and data source. The sequence length is 10 x 1250 symbols. The first slot should be activated; it starts with symbol 157, and ends approx. with symbol 305 (2 x 156.25 symbols per slot minus 8.25 symbols guard interval).
Then enter all ramp positions for the first frame.

Symbol index	Power / dB
0	-80
157	0
305	-80
1249	-80

Do not forget to specify the power value at the end of the frame (period), in this case at symbol 1249. The last entry in the ramping table indicates the period for the periodical extension. The period is greater than the index of the last entry by 1, since the symbol index starts at 0.
Next, activate the Periodically Extended Power Ramping option and look at the magnitude of the signal (r(t), phi(t)) in the range of 0 to 125000 symbols. You can see that ten frames, each with active slot 1, have been generated as required.

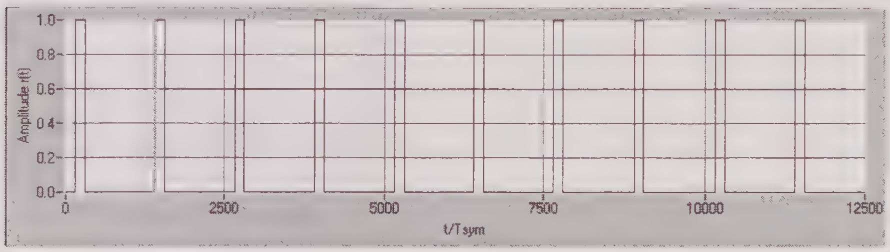


Fig. 5-50 Periodically Extended Power Ramping function

Ramp Positions: In the second window of the panel, the ramp positions and the RF signal level to be attained at the end of a ramp can be defined. The position of a ramp is determined by entering the symbol number where the ramp should begin. Starting with 0, the symbols are consecutively numbered. A ramp can be started at any position. The end of a ramp, ie the time when the signal reaches the rated level, can be defined by adding the ramp time and the ramp position.

New ramp positions and their rated levels can be entered in the **Define new ramp position** window. The position of the ramp is entered in the **Symbol** field, the rated level in the **Level** field. A level of between -80 dB and 0 dB can be set. By pressing the **Add** button, the newly defined ramp is transferred to the **Defined Ramp Positions** table. All defined ramp positions are listed in this table in ascending order. If a ramp has already been defined at the selected position, the user is asked in a dialog box whether the previous entry should be overwritten.

The user can scroll through the list using the scrollbar at the left of the table. Thus all defined ramps can be viewed. When a line is selected in the table with the mouse, the line is highlighted by an orange frame and the ramp position with level is copied into the Define new ramp position field. This function can be used for editing already defined ramps. When an entry in the table is selected and the **Delete** button is pressed, the entry is cleared from the table. The whole table can be cleared with the **Delete All** button.
Up to 512 ramp positions can be defined.

Note: *Because of baseband filtering and other components in the signal path, a delay will occur between the original, unfiltered data and the output signal of the filter. When a power ramping profile is created, the ramp positions are always related to the unfiltered data. The delays caused by the filter are automatically considered by WinIQSIM and the power ramping profile is corrected correspondingly.*

In many communications standards, the power time templates are also defined at the input data bit level. In WinIQSIM this function is contained in the data editor (see section 5.7). The settings made in the data editor can be automatically converted to the symbol level and transferred into the Power Ramping panel. To avoid the ramps defined in the data editor being inadvertently overwritten in the Power Ramping panel, the Power Ramping panel is disabled in this case. The ramp positions can be viewed but no longer edited. The Add, Delete, Delete All buttons and the fields for defining the ramp type are disabled (grey). In the top window of the panel the message **Defined by data editor** is displayed. The **Release** button is displayed in addition. With this button the Power Ramping panel can be enabled again so that the ramps can be edited as usual.

The magnitude characteristic of a signal generated with power ramping is shown in the diagram.

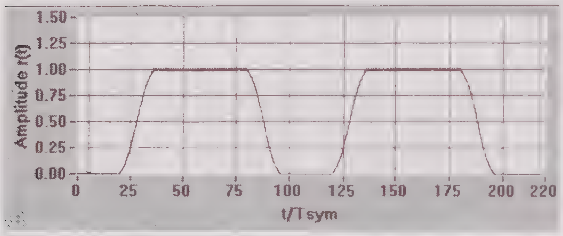
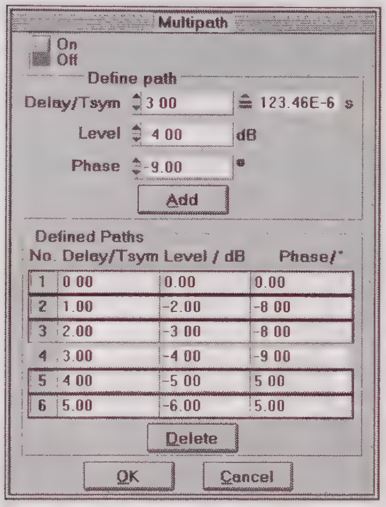


Fig. 5-51 Signal with power ramping

5.14 Multipath Panel

Electromagnetic radio waves are propagated in different directions. The waves can be reflected, refracted or scattered. As a result they arrive at the receiver on different paths and with different delays. In mobile radio communication this effect depends on the nature of the terrain, ie in mountain areas more reflected waves arrive at the receiver than in a flat area without buildings. This multipath propagation can also be simulated. Up to six paths can be configured. Multipath propagation can be enabled and disabled with the On/Off switch.



Define path

Delay/Tsym 3.00 123.46E-6 s

Level 4.00 dB

Phase -9.00 °

Defined Paths

No.	Delay/Tsym	Level / dB	Phase/°
1	0.00	0.00	0.00
2	1.00	-2.00	-8.00
3	2.00	-3.00	-8.00
4	3.00	-4.00	-9.00
5	4.00	-5.00	5.00
6	5.00	-6.00	5.00

Fig. 5-52 Multipath panel

Define Path: In this window a new path can be configured for multipath propagation. **Delay**, **Level** and the start **Phase** can be defined as path parameters.

In the **Delay** field the delay difference of the path is set normalized to the symbol duration. A value between 0 and 32 T_{symbol} can be set. Using the current symbol rate, the path delay is automatically converted to an absolute delay and displayed in seconds at the right of the Delay field.

In the **Level** field, the signal level of the path can be set in the range -80 dB and 0 dB. In the **Phase** field, the phase shift of the path is set between -180° and 180°.
With the **Add** button the newly defined path is transferred to the **Defined Paths** table where the paths are listed in the ascending order of their delay. When a path is selected in the table by a mouse click, the path parameters are transferred to the Define Path window where they can be edited. A path selected in the table with the mouse can be cleared with the **Delete** button. Up to six paths can be defined.

Note: *Path 1 is the time reference for the path delay. Its delay is always 0. Path 1 must always be present and cannot be cleared.*

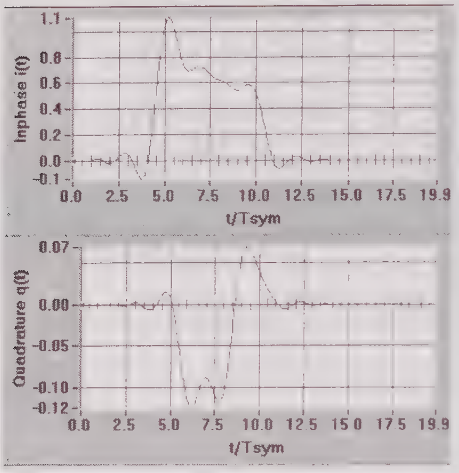
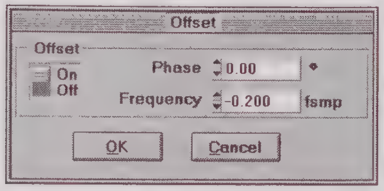


Fig. 5-53 Impulse response of a multipath constellation

5.15 Offset Panel

In the Offset panel, phase and frequency offsets can be set for the signal. This impairment can be added or removed from the signal path by means of the On/Off switch.



Phase 0.00 °

Frequency -0.200 fsmp

Fig. 5-54 Offset panel

Phase offset: In this field the phase offset can be set between -180° and 180°. The effect of the phase offset can be seen in the vector diagram. The whole diagram is rotated by the set phase offset. See also the figure below.

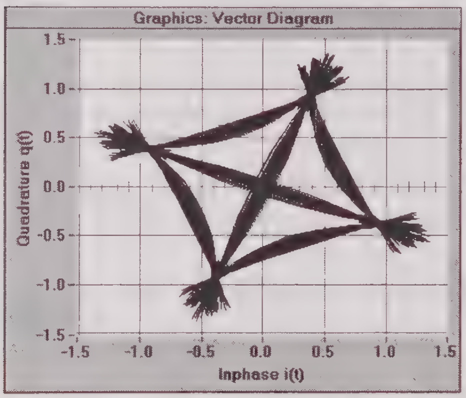


Fig. 5-55 Effect of phase offset on vector diagram

Frequency offset: The frequency offset for the baseband signal can be set here. A frequency between -0.35 f_{sample} and +0.35 f_{sample} can be set normalized to the current baseband sampling rate.
Example for the entry of the normalized frequency offset:
f_{symbol} = 100 kHz, oversampling = 12, desired frequency offset = 300 kHz
The baseband sampling rate is described by $f_{sample} = f_{symbol}$ * oversampling = 100 kHz * 12 = 1200 kHz.
The value to be set in the panel for the normalized frequency offset is therefore
f_{offset} / f_{sample} = 300 kHz / 1200 kHz = 0.25.
The diagram below shows the magnitude spectrum of a signal with frequency offset.

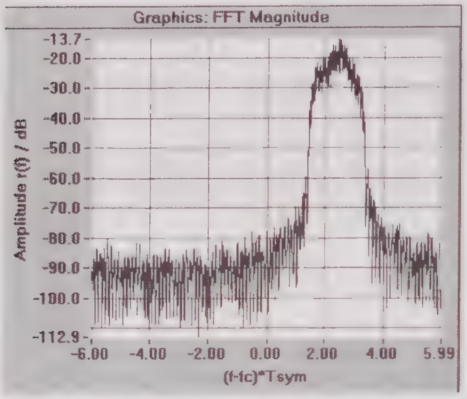


Fig. 5-56 Magnitude spectrum of signal with frequency offset

5.15.1 Assistant Function for Determining the Frequency Offset

If an I/Q signal is to be provided with a frequency offset, certain conditions of the I/Q signal and the frequency offset must be fulfilled to generate a precision signal. In particular at the wrap around point, ie the point at which the AMIQ output signal changes from the end to the start of the signal, there may otherwise be amplitude differences causing unwanted spikes in the spectrum.

The time period of the I/Q signal (without offset) must be equivalent to an integer multiple of the oscillation period with the offset frequency.

$t_{IQ-Signal} = n \cdot \frac{1}{f_{Offset}}$ $n \in \mathbb{N}^{+}$ with the time period of the I/Q signal being obtained as the ratio of sequence length and symbol rate.

The following illustration shows a constant I/Q signal with a frequency offset which does not meet the above condition. The displayed wrap around point shows distinct spikes both of the I and the Q amplitude.

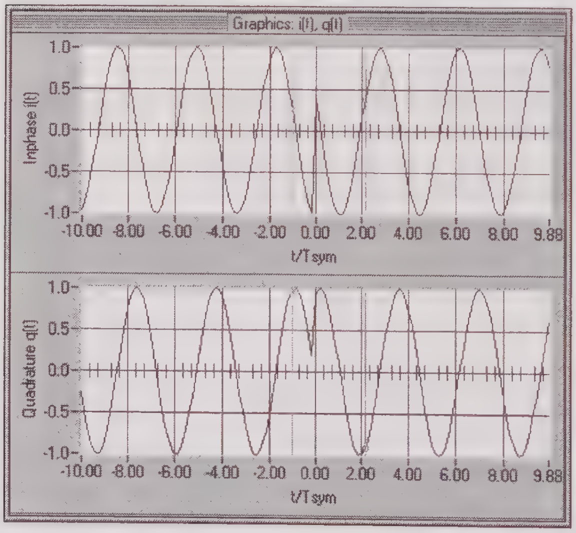
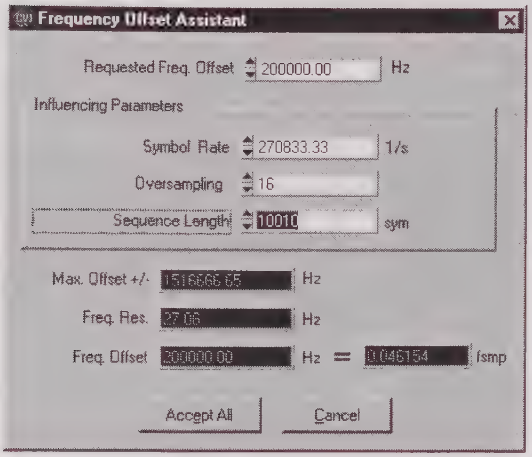


Fig. 5-57 Wrap around of I/Q signal with frequency offset set without assistant function

In order to solve this wrap around problem, the assistant function has been integrated which can be activated via the **Assistant** button in the Offset panel. After actuating this button, the following modal dialog window is opened.



Requested Freq. Offset 200000.00 Hz
Symbol Rate 270833.33 1/s
Oversampling 16
Sequence Length 10010 sym
Max. Offset +/- 1516666.65 Hz
Freq. Res. 27.06 Hz
Freq. Offset 200000.00 Hz = 0.046154 fsmp

fig. 5-58 Frequency offset assistant function

The desired frequency offset can be entered in the **Requested Frequency Offset** field. Please note that only a range between -0.35 and +0.35 of the sampling rate can be selected as offset. The maximum permissible offset is entered in the **Max. Offset** field. The max. offset can be achieved by increasing the oversampling or the symbol rate. The modulation parameters influencing the setting of the offset are entered in the **Influencing Parameters** field. The influencing parameters can be varied in this field to determine the frequency offset that does not cause any wrap around problems (**Frequency Offset** field). The resolution for varying the offset frequency without any problems is stated in the **Frequency Resolution** fields. WinIQSIM automatically selects a frequency offset that causes no problems.
The frequency resolution is defined as:

$$f_{resol} = \frac{f_{symbol}}{sequence \cdot length}$$

, ie as the ratio of the symbol rate of the I/Q signal and the sequence length in symbols. The longer the I/Q sequence, the more accurate is the setting of the offset frequency without wrap around problems.

If the panel is closed with the **Accept All** button, all set parameters are accepted whereas with the **Cancel** button all settings are discarded.

The result of setting the frequency offset with the assistant function is shown in the figure below.

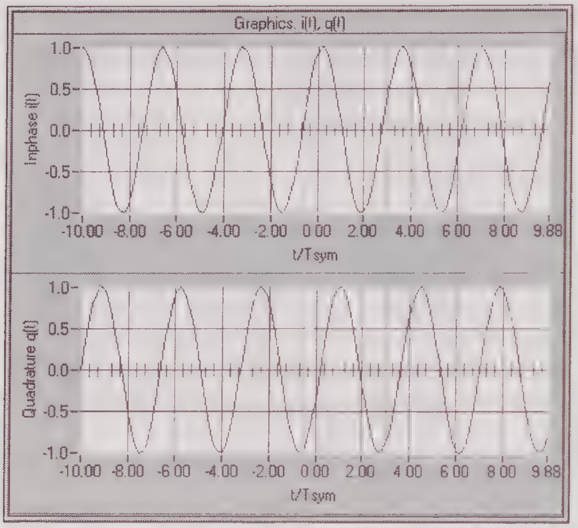
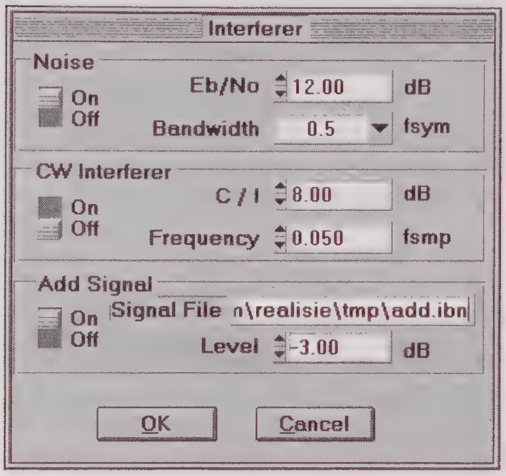


Fig. 5-59 Wrap around of I/Q signal with frequency offset set with assistant function

5.16 Interferer Panel

In this panel three different types of additive signal impairments can be configured and superimposed onto the I/Q signal. In addition to noise and simulated sinewave interferers, previously calculated, modulated signals can be added to the I/Q signal. The individual impairment types can be switched On and Off with the switches at the left of the parameter entry fields.
The three types of additive impairments are now described.



Noise
On / Off
Eb/No 12.00 dB
Bandwidth 0.5 fsym

CW Interferer
On / Off
C / I 8.00 dB
Frequency 0.050 fsmp

Add Signal
On / Off
Signal File n\realisie\tmp\add.ibn
Level -3.00 dB

Fig. 5-60 Interferer panel

5.16.1 Noise

To simulate real transmission conditions, noise can be added to the signal. In general, the ratio of the bit energy E_b to the average noise N_0 is given for specific bit error rates. However, the S/N ratio can only be exactly determined if the bandwidth of the receiver is known. The S/N ratio defined in terms of bit-energy-to-noise-energy ratio E_b/N_0 and receiver bandwidth B_{rec} is described by

$$\frac{S}{N} = \frac{E_b}{N_0} - 10\log\frac{B_{rec}}{f_{symbol}}$$

where f_{symbol} is the symbol rate of the signal. From this equation it can be seen that the S/N ratio of a receiver with a Nyquist bandwidth $B = f_{symbol}$ equals the bit-energy-to-noise-energy ratio E_b/N_0.

E_b/N_0 can be set in the range -3 dB to 80 dB. An E_b/N_0 ratio of -3 dB means that the signal level is 3 dB below the noise level.
The given receiver bandwidth **B_{rec}** is normalized to the symbol rate f_{symbol}. The ranges 0.5, 1, 2, 4, 8, 16 and Full can be selected. Full means, the receiver bandwidth is set to half the baseband sampling rate $f_{sample} = f_{symbol}$ * oversampling.

The following figure shows the constellation diagram of a QPSK signal with superimposed noise.

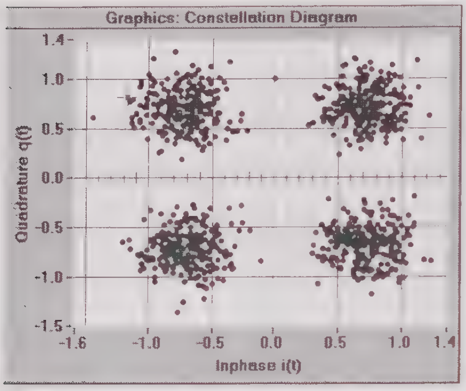


Fig. 5-61 Constellation diagram of QPSK signal with noise

5.16.2 CW Interferer

In this window a sinusoidal interferer, eg a co-channel interferer, can be simulated. The carrier-to-interferer (C/I) frequency spacing and the C/I power ratio can be set.

C/I: The carrier-to-interference ratio can be defined between -3 dB and 80 dB.

Frequency: The carrier frequency of the interferer f_{sample} can be set between - 0.35 f_{sample} and + 0.35 f_{sample} normalized to the baseband sampling rate.
The figure below shows the magnitude spectrum of a QPSK signal with the CW interferer switched on.

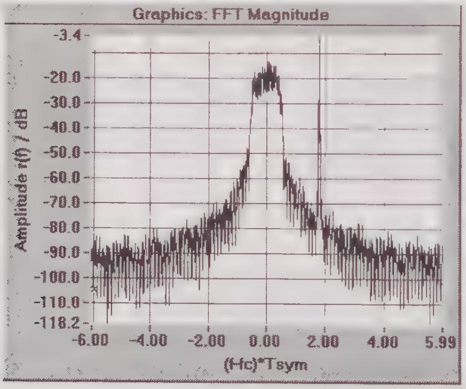


Fig. 5-62 Magnitude spectrum of QPSK signal with CW interferer

5.16.3 Add Signal

In this window a previously calculated and stored signal can be added to the I/Q signal. It should be noted that the baseband sampling rate of the added signal must not be greater than that of the useful signal. The signals can be added when the sampling rates are equal. If the added signal has a lower sampling rate, the rate of the added signal has to be converted to the sampling rate of the useful signal. This is done internally by means of a resampler. According to Shannon, the sampling rate can be increased without any loss in information. Since resampling is a complex operation, it may take up some time when the ratio between the previous and the new rate is unfavourable and sequences are long. For this reason a progress indication bar is displayed during resampling. To avoid time-consuming calculations, make sure that the difference between the sampling rate of the added and of the useful signal is not too great.

To obtain useful results after the addition, the two signals should also have the same length. The product of sequence length and symbol duration should be the same. If the signal to be added is too long, only the first part of the signal will be used. If it is too short, the signal period is automatically continued.

Signal File: In this field the added signal file is displayed. To select a file click into the field with the left mouse key. A file selection window is opened where a signal file with the fixed extension ***.ibn** can be selected for addition to the I/Q signal.

Any signal calculated in WinIQSIM can be stored in this format and added to other signals later on. To do so select **Save for Add** in the File menu. The configured signal is then stored in a file of your choice (with the extension *.ibn).
Level: In this field the level of the added signal can be set in the range -80 dB to +3 dB. A level of +3 dB means that the amplification of the added signal is higher by 3 dB than that of the I/Q signal.

When used together with the Frequency option in the Offset panel, the Add Signal function can be used to simulate a signal containing several carriers. As an example a signal with three channels or carriers should be generated. The center frequency of the first channel should be at the left of the RF carrier, that of the second exactly at the carrier frequency and that of the third at the right of the carrier.

- Define the first signal channel by selecting data and modulation as usual.
- Set a negative frequency offset for the channel in the Offset panel and switch on the Offset block.
- Store this signal as channel1.ibn under the File:Save for Add menu.
- Define the second signal channel with data and modulation.
- Switch off the Offset block because no carrier frequency offset should be set for channel 2.
- Switch on the Add Signal block and select the previously stored file channel1.ibn as file to be added.
- Store the new two-channel signal configuration as chan1_2.ibn under File:Save for Add.
- Define the third channel as required.
- Set a positive frequency offset for the channel in the Offset panel and switch on the Offset block.
- Switch on the Add Signal block and select the previously stored file chan1_2.ibn as file to be added.
- The spectrum of the completely configured three-channel signal can now be displayed in the Graphics panel where the settings can be checked.

The result of the described procedure for a QPSK signal is shown in the following diagram .

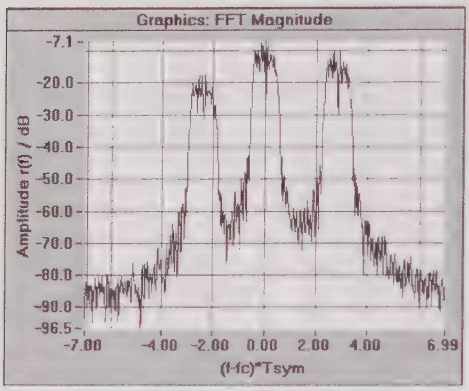
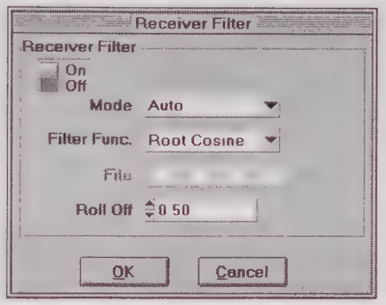


Fig. 5-63 Magnitude spectrum of three-channel QPSK signal

5.17 Receiver Filter Panel

In some communication standards, channel filtering is split into a transmitter filter and a receiver filter. To optimize the S/N ratio, matched filters are often used in the receivers. The impulse response of these filters corresponds to that of the baseband filter in the transmitter (for an ideal channel and a real, symmetrical pulse). The effects of such a receiver filter on the I/Q signal can be simulated in this panel. Using the On/Off switch, the receiver filter can be cut into or removed from the signal path. The time and frequency response of the receiver filter corresponds to that of the baseband filter described in section 5.8.5.


Receiver Filter

Receiver Filter

○ On
● Off

Mode: Auto

Filter Func.: Root Cosine

File

Roll Off: 0.50

Fig. 5-64 Receiver Filter panel

Mode: Three different modes can be selected for the receiver filter. In the **I/Q** mode, an I/Q demodulator (coherent demodulator) is assumed to be in the receiver. The **FM** mode assumes an FM demodulator. With **Auto** selected, an I/Q modulator is used for the modulation types PSK, QAM and GMSK or an FM modulator for 2FSK, 4FSK and GTFM.

Filter function

A rectangular, root cosine, Gaussian or a user filter function can be selected. Since these filters are described in detail in section 5.8.5 only a brief description will be given here.

Rectangular filter (Rect): The impulse response of the rectangular filter is a rectangular pulse with a width of one symbol period T_{sym}. The filter response shows a sin(f) / f characteristic. The rectangular filter should be used for PSK and QAM modulation methods for which specific filter characteristic is not required.

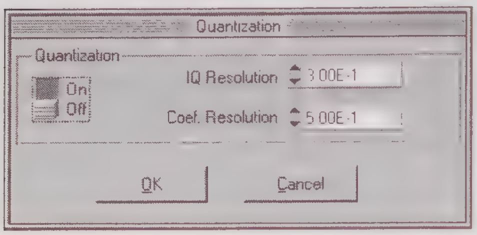
Square root raised cosine filter (Root Cosine): The filter response and the impulse response of the root cosine filter are described in section 5.8.5. Parameter α is the **roll-off factor.** It determines the skirt selectivity of the filter in the time domain and the passband in the frequency domain. With WinIQSIM, a roll-off factor between 0.01 and 0.99 can be set in the **Roll Off** field below the Filter Function field. The roll-off field is displayed alternately with the entry fields for other filter types.

Gaussian filter (Gauss): When the Gaussian filter is used, the filter response has the shape of a Gaussian bell. The filter characteristic can be influenced by the product of period and bandwidth B * T. B is the 3 dB filter bandwidth and T the symbol period. This normalized bandwidth B * T can be set in the range from 0.1 to 10 with a 0.01 resolution. The value is set in the **B * T** field below the Filter Function field. This field is displayed alternately with the field for the roll-off factor.

User filter: To allow the user to load filter types that are not predefined by WinIQSIM, a user-specific filter can be configured via a data file. Selecting the User Filter function opens a window where a file with the extension ***.IRF** (IQSIM receiver filter file) can be selected. This filter file has the same format as the baseband filter described in section 5.8.5. The selected filter file is displayed in the **File** field.

5.18 Quantization Panel

In modern communications systems, digital components like signal processors are used to an increasing extent. These components feature a limited computing accuracy because the number of bits available resolution is finite. The use of D/A converters also limits signal resolution. For this reason the resolution of filter coefficients and I/Q signals can be set in WinIQSIM. With the On/Off switch, quantisation can be enabled and disabled.



IQ Resolution 3.00E-1

Coef. Resolution 5.00E-1

Fig. 5-65 Quantization panel

IQ Resolution: The resolution of I/Q values can be set between 10^{-6} and 0.5. Example: With a resolution of 0.002 set, all input values of a block are displayed on the next integral multiples of 0.002 (0.4567 => 0.456). Assuming an input value range of -1 to 1 for I and Q, a resolution of 0.002 permits 1000 amplitude steps to be generated. This corresponds to a resolution of approx. 10 bits for I and Q.

To simulate the use of n bits for I and Q, the input value range from -w to w is first to be considered (normally w will be about 1).

To calculate the resolution to be set, divide the input value range (2*w) by the number of amplitude steps which is to be displayed with n bits (2^n). For instance, with n = 8 bits and W = 1, a resolution of 2* 1 / 256 = 1/128 is obtained for I and Q.

Coefficient Resolution: The resolution of filter coefficients can be set in the same way as the resolution for I and Q. The coefficient resolution can be set in the range between 10^{-6} and 0.5. The figure below shows the impulse response of a Gaussian filter with and without quantisation.

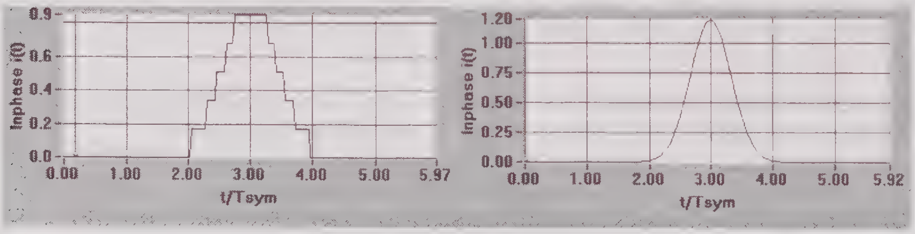
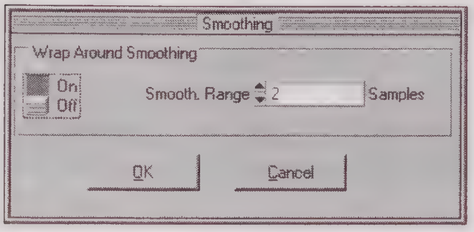


Fig. 5-66 Effect of quantisation on the impulse response of a Gaussian filter

5.19 Smoothing Panel

In many cases the I/Q signal is a loaded I/Q sequence which is continuously output. In this case amplitude differences may occur between the end of a sequence and the beginning of the next (wrap around point). These wrap arounds can be smoothed in the Smoothing panel. Smoothing can be enabled and disabled with the On/Off switch.



Smooth. Range 2 Samples

Fig. 5-67 Smoothing panel

Smoothing Range: A value between 2 and 32 samples can be set for the smoothing range (with an oversampling of 8, 8 samples are obtained from one symbol).

The signal is smoothed by filtering the points of the I and Q sequence in the wrap around range. The new trace value is obtained from the weighted average of the previous value and from the values of the neighbouring points at the right and left. The **Show wrap around** option can be selected in the Graphics Settings panel for the formats i(t), q(t) and r(t), phi(t). With this option selected, the wrap around range of the signal is displayed to decide whether the signal requires smoothing or not.

5.20 Graphic Setting and Graphics Panel

The graphics panel is an important tool for viewing and checking the signal configuration. In this panel the generated I/Q signal or representations derived thereof like the vector diagram or the signal spectrum can be displayed. Cursor and zoom functions are available for a close examination of the signal and for reading characteristic values.

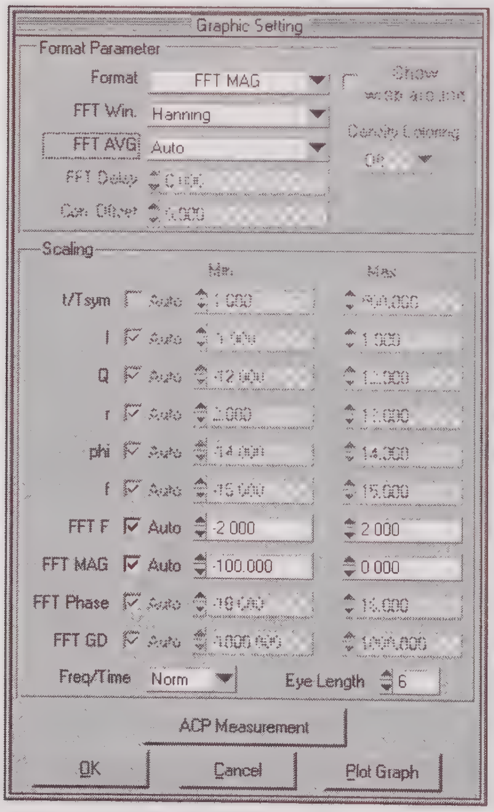
In the Graphic Setting panel the display format can be selected and the respective graphics parameters set. The scaling can also be selected. The Graphic Settings panel allows changes to be made in the Graphics panel.

In the Graphics panel the signal values are displayed in the selected format. Depending on this format, one (spectrum) or two (i(t) and q(t)) diagrams are displayed. The cursor and zoom functions are available in the Graphics panel.

Parameters for setting a graphics format in the Graphic Setting panel and the pertaining display in the Graphics panel will be described together. The configuration of the two panels and the functions that are independent of the selected display format are described first.

5.20.1 Graphic Setting Panel

The Graphic Settings panel comprises two windows. In the **Format Parameter** window the graphics formats and the pertaining graphics parameters can be set. The **Scaling** window is used for defining the scale of the display.



Graphic Setting

Format Parameter

Format: FFT MAG

FFT Win.: Hanning

FFT AVG: Auto

Scaling

		Min	Max
t/Tsym	☐ Auto	1.000	[illegible]
I	☑ Auto	[illegible]	1.000
Q	☑ Auto	[illegible]	[illegible]
r	☑ Auto	[illegible]	[illegible]
phi	☑ Auto	[illegible]	14.000
f	☑ Auto	-15.000	15.000
FFT F	☑ Auto	-2.000	2.000
FFT MAG	☑ Auto	-100.000	0.000
FFT Phase	☑ Auto	[illegible]	[illegible]
FFT GD	☑ Auto	[illegible]	[illegible]

Freq/Time: Norm

Eye Length: 6

Fig. 5-68 Graphic Setting panel

Format Parameter

In this window the graphics formats and the associated parameters can be set. An overview of available formats is given in the table below.

Table 5-26 Overview of graphics formats

Graphics format	Description
i(t), q(t)	Display of in-phase i(t) and quadrature q(t) component versus time.
r(t), phi(t)	Display of signal magnitude r(t) and phase phi(t) functions calculated from i(t) and q(t) versus time.
r(t), f(t)	Display of signal magnitude r(t) and instantaneous frequency f(t) versus time.
Eye diagram i	Eye diagram of i(t) displayed with a selectable eye length.
Eye diagram q	Eye diagram of q(t) displayed with a selectable eye length.
Eye diagram f	Eye pattern for f(t) displayed with a selectable eye length. This display is of particular interest for FSK modulation.
Vector	Display of signal characteristic q(t) versus i(t). This display is called vector diagram.
Constellation	Display of q(t) versus i(t) in the constellation diagram. However only the signal values at the ideal symbol sampling times are displayed.
FFT MAG	Display of magnitude spectrum of the I/Q signal versus frequency.
FFT Phase	Phase display of I/Q signal spectrum versus frequency.
FFT GD	Display of signal delay versus frequency.

A detailed description of the formats and their parameters is given in section 5.20.3.

Scaling

In the Scaling window, the axes of the diagrams in the Graphics panel can be scaled. The scale of the abscissa (x axis) and ordinate (y axis) can be set automatically (autoscaling) or by the operator as required.

Two graphs are displayed for the formats [i(t), q(t)], [r(t), phi(t)] and [r(t), f(t)] and one only for all others.

When two graphs are displayed, a different scale can be set for the two abscissas (time axes). For reasons of clarity this capability is however not used. The abscissas are scaled together. The ordinate axes can be scaled separately.

Thus the abscissa axis and, depending on the graphics format, one or two ordinate axes can be scaled in the Scaling window.

Autoscaling and User Scaling

For all parameters displayed in the Graphics panel (t, I, Q, r, phi, f, FFT F, FFT MAG, FFT Phase, FFT GD), you can define whether the corresponding axes are to be scaled automatically or by the user.

For each of these parameters, the display range [Min, Max] for the parameter axis in question can be selected in the **Max** and **Min** fields right of the Autoscaling field. The settable range depends on the graphics format, oversampling and a few other parameters. The Min value should always be lower than the Max value to avoid an error message being output. With Autoscaling selected, the set range values have no effect. The axes are scaled automatically.

Only the parameters required for a given graphics format are accessible for scaling, the remaining parameters are dimmed.

When a signal is displayed for the first time, the Autoscale option should be selected for all axes to see in which range the signal is displayed. Then any scale can be chosen and any display format selected.

The entry fields for Freq/Time and Eye Length are only of interest for some graphics formats. They will be described in section 5.20.3 together with the formats.

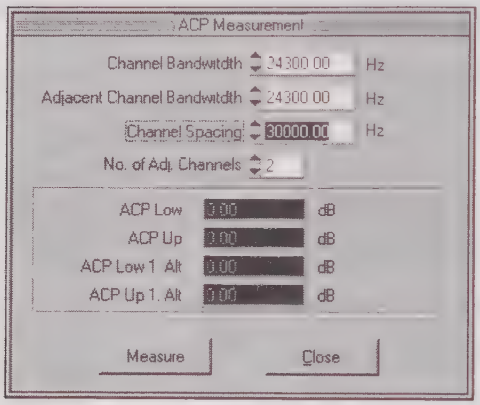
After selecting format and scale for the graphs, the diagrams are displayed when the Plot Graph button is pressed. The I/Q signal is calculated when this has not been done before. The graphics format is determined by the I/Q data and displayed in the Graphics panel.

The ACP Measurement button permits to open a panel where the adjacent-channel power can be determined in the FFT graphics. These functions will be described further down.

The Graphics panel is closed with OK or Cancel. When Cancel is pressed, all the settings made are rejected.

5.20.1.1 ACP Measurement

WinIQSIM permits to determine the adjacent-channel power of the configured IQ signal.
This function is only accessible when the graphics format FFT is set. To this end, actuate the ACP Measurement button in the Graphic Settings Panel, and the following panell will appear.



Channel Bandwidth 24300.00 Hz
Adjacent Channel Bandwidth 24300.00 Hz
Channel Spacing 30000.00 Hz
No. of Adj. Channels 2
ACP Low 0.00 dB
ACP Up 0.00 dB
ACP Low 1. Alt 0.00 dB
ACP Up 1. Alt 0.00 dB

Fig. 5-69 ACP Measurement Panel

WinIQSIM can determine the power in the two right and left adjacent channels relative to the power of the useful channel. The displayed ACP values are not meant to be understood as values that can be remeasured using spectrum analyzers, since only the parameters of the ideal IQ signal are determined here. Besides, the influence of the selected FFT window and of averaging is not to be underestimated. This function can be used, for example, in order to optimize filter parameters with respect to the ACP, ie in order to compare different signal configurations.

In the panel, it is possible to set the bandwidth of the useful channel in the field **Channel Bandwidth**, the bandwidth of the adjacent channels in the field **Adjacent Channel Bandwidth** and the channel spacing in the field **Channel Spacing** in the range between 10 Hz and half the currently set sampling rate. The currently set sampling rate is displayed in the status line. In most cases, the bandwidth of the useful channel is identical to that of the adjacent channels. There are also cases, however, where the RF leakage of a system A is to be determined in the adjacent channels of system B. Therefore, the parameters Channel Bandwidth and Adjacent Channel Bandwidth can be set independently of each other. As a prerequisite for the ACP measurement in WinIQSIM, the channel spacing must be at least as large as the channel bandwidths set.

The field **No. of Adj. Channels** permits to select whether only one or both the lefthand and righthand adjacent channels are to be examined. Note that the required test bandwidth must not exceed the currently set sampling rate. The following condition must be fulfilled:

$$No\_of\_ACP\_Channels * Channel\_Spacing + \frac{Adjacent\_Channel\_Bandwidth}{2} \leq \frac{Sample\_Rate}{2}$$

The following drawing illustrates the importance of the ACP measurement parameters. The useful channel is called Main Channel, the lefthand adjacent channel (lower frequency) Lower Channel and the righthand adjacent channel Upper Channel (higher frequency). The two outer channels are additionally assigned Alternate.

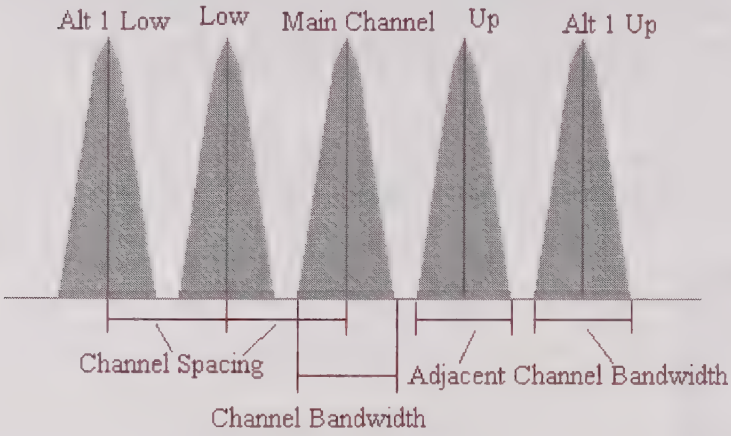
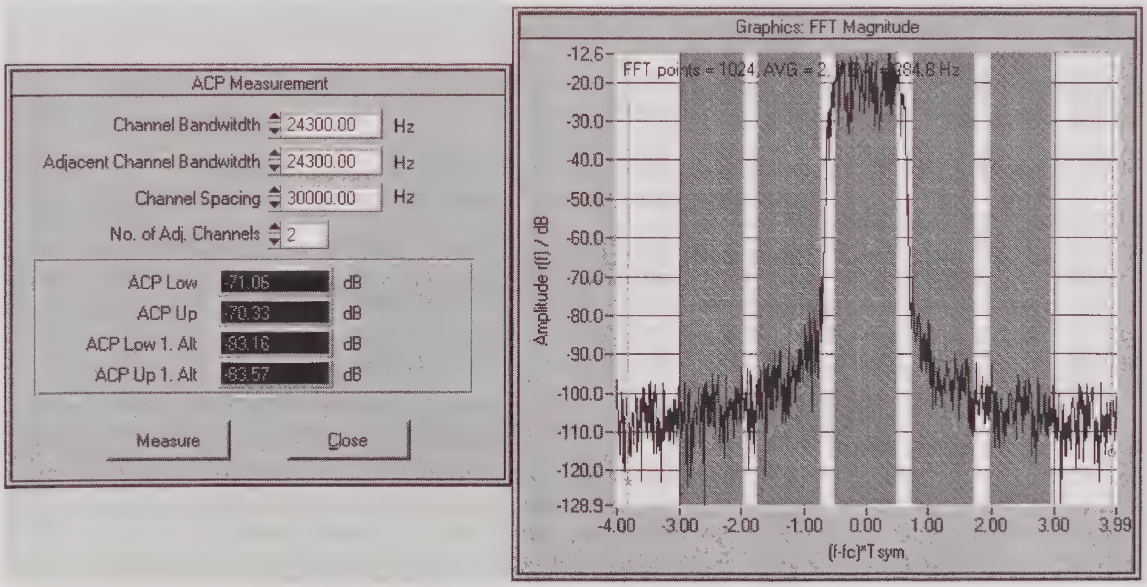


Fig. 5-70 Drawing ACP Parameters

In order to start an ACP measurement press the **Measure** button. The calculated ACP values are indicated in the display fields ACP Low, ACP Up, ACP Low 1. Alternate and ACP Up 1. Alternate in dB relative to the power of the useful channel. The individual channel powers are internally normalized to their associated channel bandwidth. The channel ranges defined for the ACP measurement are highlighted in colours in the Graphics panel.


ACP Measurement

Channel Bandwitdth 24300.00 Hz
Adjacent Channel Bandwitdth 24300.00 Hz
Channel Spacing 30000.00 Hz
No. of Adj. Channels 2

ACP Low -71.06 dB
ACP Up -70.33 dB
ACP Low 1. Alt -83.16 dB
ACP Up 1. Alt -83.57 dB

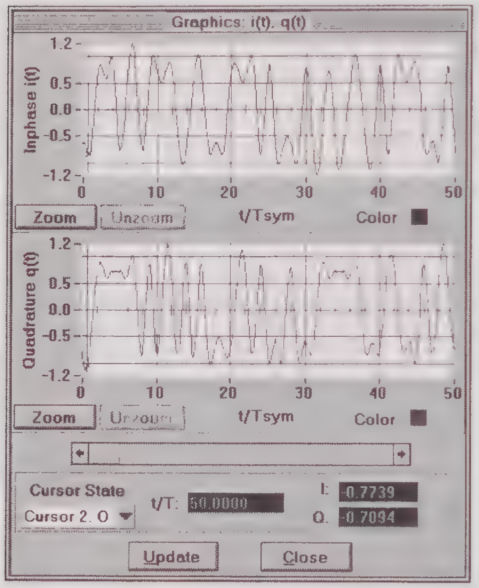
Fig. 5-71 FFT graphics with channel ranges entered

An update of the graphics panel automatically involves an update of the ACP measurement if the ACP panel is active.
The Close button permits to close the ACP panel.

5.20.2 Graphics Panel

In the Graphics panel the calculated I/Q signal is displayed in the selected format. The selected format is indicated in the headline of the panel. Depending on this format, one or two graphics windows are displayed. The elements for zooming and selecting the colour for the graphs are displayed below the display windows. A scrollbar is provided in addition for changing the display range of the graphs. Two cursors are displayed in the graphics windows to simplify reading.

The size of the Graphics panel can be changed as required using the mouse. However, the window size cannot be reduced below an internally set minimum value. This ensures that the graphs displayed and the control elements are always visible and ready for use.



Cursor State: Cursor 2. O
t/T: 50.0000
I: -0.7739
Q: -0.7094

Fig. 5-72 Graphics panel

Selection of graph colours
The colour used in the displays can be selected in the **Color** fields at the right below the display windows. To select a colour click on the Color field with the left mouse key and hold the key down. A colour selection window is opened. With the mouse key still held down, a colour can now be selected with the aid of the mouse cursor. After the selection release the left mouse key. The selected colour is indicated in the Color field. It is set when the next graph is drawn or the **Update** button (at the bottom of the panel) is pressed.

Scrolling the display range
For all graphics formats using time t as the abscissa, a scrollbar is provided for selecting the displayed time span. The length of the shiftable element in the bar is proportional to the displayed time span. The total length of the scrollbar corresponds to the calculated period of the whole signal. With Autoscale selected for the time axis, the size of the displayed time span is set automatically.

If the axis is scaled by the user, the displayed signal period corresponds to the difference between the values set in the Graphics Setting panel for **Left** and **Right** when the user scrolls through the range.

Example: The signal was calculated for 100 symbols. The permissible span for the time axis is therefore t = 0 to t = 100 T_{symbol}. 5 T_{symbol} is set as range limit at the left and 15 T_{symbol} at the right (autoscaling off, format i(t), q(t)). When the graph is drawn for the first time a time span of 5 to 15 T_{symbol} is displayed. If another range is selected with the aid of the arrow keys of the scrollbar or by shifting the scrollbar with the aid of the mouse, a signal section of (15 - 5) T_{symbol} = 10 T_{symbol} will always be displayed.

Graph cursors

Two cursors are available in each graph. The cursors are **snap-to-point** cursors which means that they lock to the next value on the displayed trace when they are moved with the mouse.

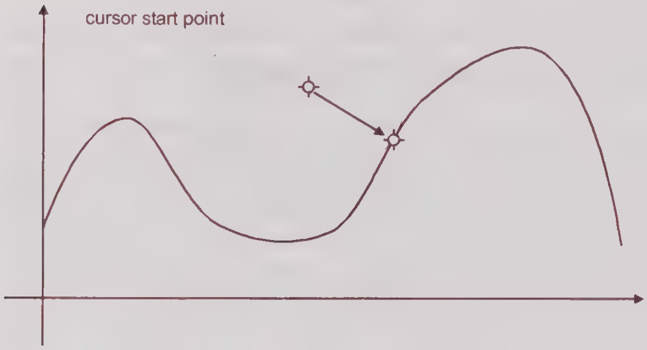


Fig. 5-73 Function of snap-to-point cursors

An **X** is marked on the trace at the position to which the **red cursor** locks and an **O** at the position to which the **green cursor** locks. If two graphs are displayed, cursors of the same colour are linked, ie they are automatically positioned on the same coordinate of the abscissa. If a cursor is moved within a graph, the corresponding cursor in the second graph is automatically set to the same position.
The cursors can be moved by means of the mouse. A cursor activated by the mouse (to be identified by the bold vertical cursor line) can also be controlled via the keyboard. The cursor in the graph can be shifted by always one sample with cursor keys ← and →. Thus a position in the graph that was coarsely selected with the mouse can be exactly marked. With the **Home** and **End** key, the cursor can be positioned at the beginning and end of the displayed span. Switchover between the two cursors is possible with the **Page up** and **Page down** keys.
The abscissa and coordinate values of the cursors are indicated in a window below the graph(s). Three different cursor modes can be selected and set in the **Cursor State** field.

Cursor 1: X The values of the two red cursors at position X are indicated in the fields at the right of the Cursor State field. The indication fields are labelled with the displayed unit.

Cursor 1: O The values of the two green cursors locked at position O are indicated in the fields at the right of the Cursor State field. The indication fields are labelled with the displayed unit.

Delta: X - O The difference between the red and green cursor of a graph is indicated in the fields at the right of the Cursor State field. The value of the red cursor (X) is subtracted from that of the green cursor (O). Each indication field is labelled with the displayed unit. This mode is particularly useful for defining the distance between two points in the graph (eg spectrum maxima).

Zooming in the graph

Zooming in a graph, ie expanding a range of particular interest, can be performed in different ways:

- An area of special interest in the display can be zoomed by switching off autoscaling of all axis in the Graphic Setting panel and setting the range limits to the area to be zoomed.
- A more convenient and simpler method is the use of the **Zoom button** at the left below each graph. When this button is pressed, the displayed mouse cursor (arrow in most cases) assumes the shape of a zoom cursor (hand with a pointing finger). Position this cursor in the top left-hand corner of the graph area to be zoomed. Press the left mouse key and hold it down. Move the mouse cursor to the bottom right-hand corner of the section to be zoomed. While you move the cursor, a red rectangular frame will be drawn between the start point and the current cursor position. The frame marks the area to be zoomed. When the mouse has arrived at the end of the area to be zoomed, ie when the whole area is within the red frame, release the left mouse key. The selected area is shown expanded and the mouse cursor assumes its original form. The **Unzoom** button is enabled. With this button the original graph can be restored. Zooming can be performed as often as desired in succession. What is required each time is to press the zoom button and to repeat the described procedure. If two graphs are displayed, the section of the abscissa zoomed in one graph is automatically zoomed in the other. A separate Zoom and Unzoom button is provided for each graph. Zooming can only be performed in the graph the Zoom button of which has been pressed.
- Zooming can also be performed with the aid of the mouse and the keyboard. Position the cursor with the mouse on a point of the graph the area of which should be further examined. Press the **Ctrl** key on your keyboard and hold it down. Press the left mouse key. The area around the mouse cursor is expanded as long as the mouse key is held down. To compress the area around the mouse cursor, perform the described procedure with the right instead of the left mouse key. When the Ctrl key is pressed together with the space bar, the original size of the graph is restored.

To avoid the I/Q values being recalculated each time a signal parameter is changed, the graphics display of WinIQSIM is only updated when desired by the user. An update can be triggered with the **Update** button in the Graphics panel. The same result is obtained with the **Plot Graph** button in the Graphic Settings panel or by selecting Show Graphic in the Graphics menu.

5.20.3 Parameters and Display of Graphics Formats

This section describes the eleven graphics formats and their parameters in the Graphic Setting panel. A graph will be shown as an example for each format.

5.20.3.1 In-Phase i(t) and Quadrature q(t) Components

The in-phase i(t) and quadrature q(t) components of a signal are displayed in two separate graphs as a function of time. When the **Show wrap around** option (at the right of the format selection field) is selected, the wrap around area of the signals is displayed. This is the area between the end of a signal and the beginning of the next when the signal is continuously output by the I/Q source. A maximum of ten symbols is displayed at the end of a signal and not more than ten of the next. Large differences in amplitude at the wrap around position may disturb the signal spectrum. The display of the wrap around position is particularly useful for assessing the necessity and effectiveness of the Smoothing block (see section 5.19).

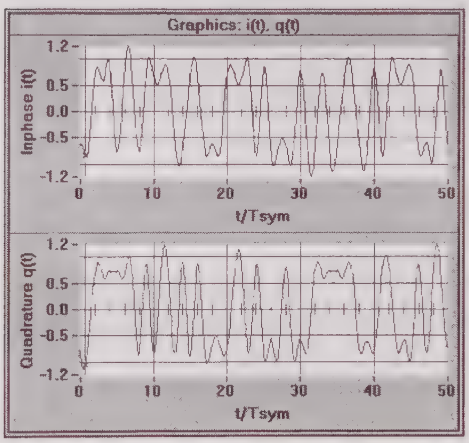


Fig. 5-74 Display of i(t), q(t)

5.20.3.2 Magnitude r(t) and Phase phi(t)

Magnitude and phase of the signal are displayed in two separate windows as a function of time. The **Show wrap around** option has the same function as for the previous format. The magnitude characteristic is particularly useful for observing the effects of power ramping. The individual level steps and the ramps are shown in the diagram.

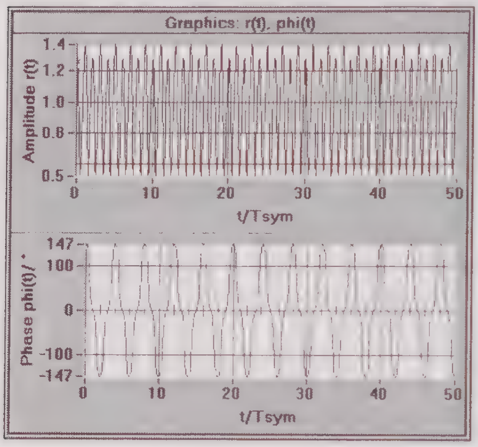


Fig. 5-75 Display of r(t), phi(t)

5.20.3.3 Magnitude r(t) and Instantaneous Frequency f(t)

The amplitude r(t) and the instantaneous frequency f(t) determined by phase differentiation are displayed in two separate plots as a function of time.

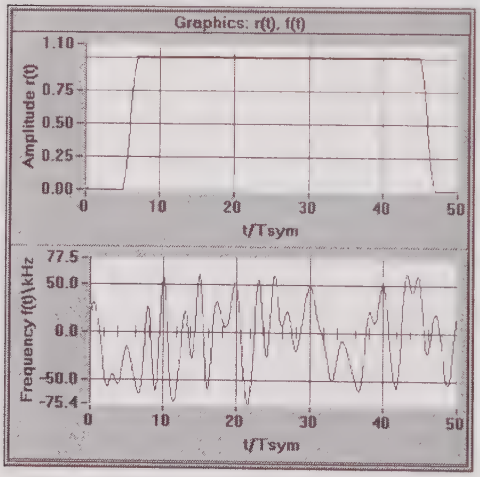


Fig. 5-76 Display of r(t), phi(t)

5.20.3.4 Eye Pattern for I

The eye pattern for i(t) is displayed. An eye length between 1 and 10 symbol periods T_{symbol} can be set in the **Eye Length** field. The signal i(t) is divided into successive segments of the set eye length. These segments are displayed on top of each other. The result is a pattern that gives the impression of an eye. The horizontal and vertical eye openings are a measure for signal distortion and intersymbol interference. A wide eye opening indicates that the signal is only slightly distorted and can be clearly identified by the receiver. If the eye is hardly open or completely closed, elaborate distortion correction has to be performed in the receiver before the signal can be demodulated.

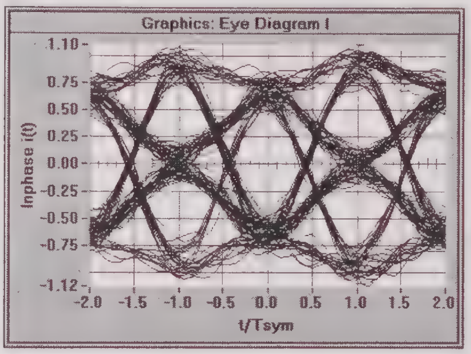
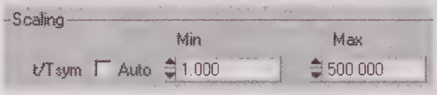


Fig. 5-77 Display of eye pattern I

If you want to display the vector diagram only of part of your IQ signal, for example because it is a burst signal, the desired signal section can be selected in the Graphic Setting panel.


Scaling
Min Max
t/Tsym ☐ Auto 1.000 500 000

To this effect, deactivate the Autoscaling option for the time axis and set the time interval using the Min and Max fields.

5.20.3.5 Eye Pattern for Q

The eye pattern for q(t) is displayed. An eye length between 1 and 10 symbol periods T_{symbol} can be set in the **Eye Length** field. The eye pattern q(t) is created in the same way as eye pattern i(t).

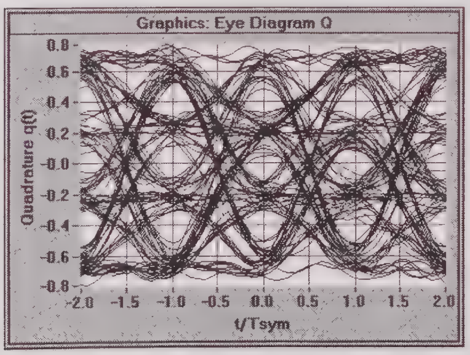


Fig. 5-78 Display of eye pattern Q

If you want to display the eye pattern only of part of your IQ signal, proceed as described in section 5.20.3.4

5.20.3.6 Eye Pattern for F

The eye pattern for f(t) is displayed. An eye length between 1 and 10 symbol periods T_{symbol} can be set in the **Eye Length** field. The eye pattern F(t) is created in the same way as the pattern for i(t). This display is particularly suitable for assessing the quality of FSK signals.

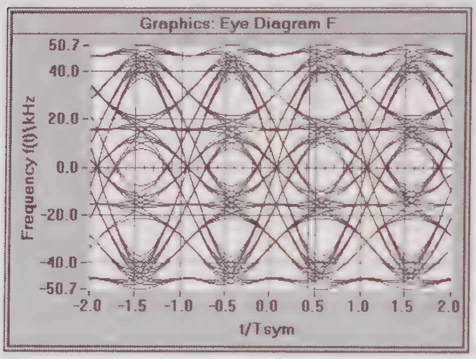


Fig. 5-79 Display of eye pattern F

If you want to display the eye pattern for F of part of your IQ signal, proceed as described in section 5.20.3.4.

5.20.3.7 Vector Diagram

In the vector diagram, q(t) is displayed versus i(t) as a parametric trace. In this display the transitions between the different states of modulation mapping can be viewed. To highlight the position of the cursor in the diagram, a white triangle with a black frame is displayed at the cursor position. With the **Home** key of your keyboard the cursor can be positioned at the start point of the diagram. Using the (← and →) cursor keys of your keyboard it can be moved through the diagram from sample to sample to view the status transitions. The **End** key positions the cursor on the last signal point in the diagram.

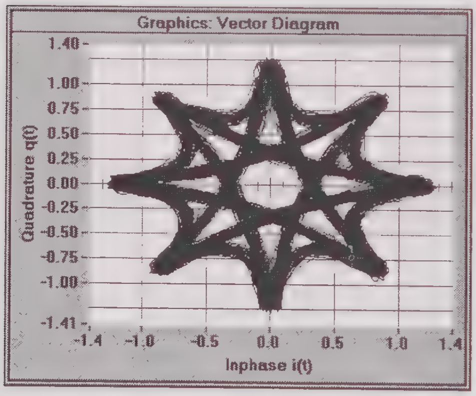
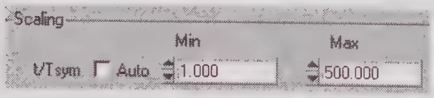


Fig. 5-80 Display of vector diagram

If you want to display the vector diagram of part of your IQ signal, proceed as described in section 5.20.3.4.


Scaling

		Min	Max
t/Tsym	☐ Auto	1.000	500.000

To this effect, deactivate the Autoscaling option for the time axis and set the time interval using the Min and Max fields.

5.20.3.8 Constellation Diagram

In the constellation diagram too, q(t) is displayed versus i(t) as a parametric trace. However, in this case only one i and one q value is displayed per symbol (value at the ideal sampling point of the symbol). The signal points in the diagram are not linked by direct lines but displayed in the form of spots. This display clearly shows the transitions between the different states of modulation mapping. The cursor position in the diagram is marked by a white triangle with a black frame. With the **Home** key of your keyboard, the cursor can be positioned at the start point of the diagram. It can then be moved through the diagram from symbol to symbol by means of the (← and →) cursor keys of your keyboard to view the status transitions. With the **End** key the cursor can be positioned on the last symbol in the diagram. In some communication systems, signal filtering is split up in a filter section in the transmitter and another in the receiver. To obtain a clear constellation diagram, a suitable receiver filter has to be connected into the signal path (see section 5.17).

The **Constellation Offset**, which can be set in the range -0.5 T_{symbol} to 0.5 T_{symbol}, shifts the sampling points in the constellation diagram in time by about the set offset. This allows signal sampling in the receiver to be simulated and displayed at a non-ideal point.

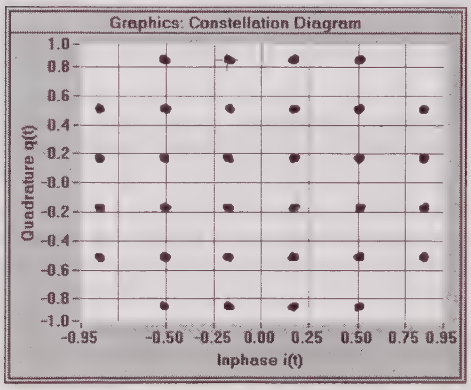


Fig. 5-81 Display of constellation diagram

Two additional options can be selected for the Constellation graphics format under **Density Coloring**. With **Density Coloring ON** selected, the points in the constellation diagram are coloured relative to their frequency of occurrence. To this end, a grid is put above the set display range of the constellation diagram and the number of points falling into the individual grid areas is determined. Then the grid areas (rectangles) are entered into the graph. Grid areas with only little points are displayed in black, those with a great number of points in yellow. The effect of this option is similar to the display of a signal on the oscilloscope. If Density Coloring All is selected in addition, all calculated signal points are displayed in this way.

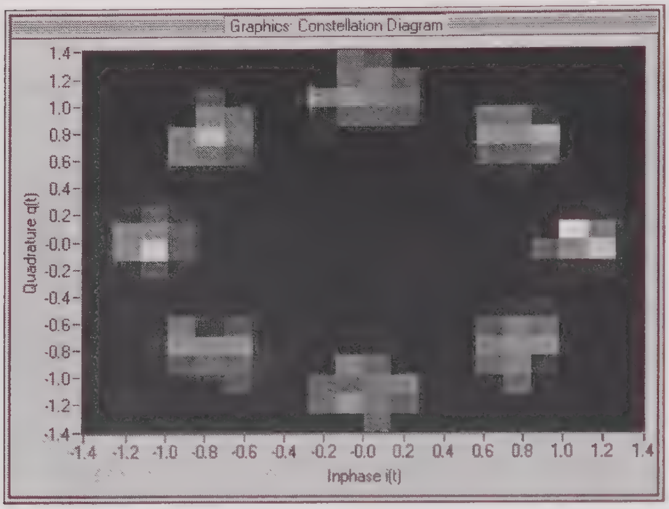


Fig. 5-82 Display of constellation diagram with density colouring

5.20.3.9 Magnitude Spectrum

The signal spectrum is calculated from the I/Q signal by means of FFT (fast Fourier transform). At first only one section of the signal in the time domain is used for the calculation. If sufficient signal points are available, 8192 (8k) points are used for the FFT calculation (otherwise a correspondingly smaller number of points). To avoid the generation of spurious spectrum lines as may be produced from this section due to FFT calculation, the signal section has to be windowed before FFT is performed. The window function should smooth the signal edges. Four window functions can be selected in the **FFT Window** field: Rectangle, Hanning, Flat Top and Blackman. Selecting a rectangular window means that no filtering is performed.

Depending on the selected type of modulation, a rough, irregular spectrum may be obtained. To smooth the spectrum, the **FFT Average** function can be used. An averaging number of Auto, 1, 2, 4, 8 16, 32, 64, 128 or 256 can be selected. The spectrum display is averaged over a number of spectra obtained with FFT for several consecutive sections of the signal in the time domain. FFT Average determines the number of sub-spectra to be averaged. With Auto selected, averaging is determined by WinIQSIM so that all calculated IQ values will be used for determining the spectrum.

For FFT calculation of the sub-spectra, 8192 points are used as well. If the total number of signal points is smaller than **Average * 8192**, a correspondingly smaller number of points is used for FFT calculation.

Under **Freq/Time** a selection can be made whether an absolute frequency axis or a frequency axis normalized to the symbol rate should be used.

The spectrum display allows a check of calculated values particularly when multicarrier signals are generated.

With **FFT MAG** selected, the magnitude of the displayed spectrum is displayed versus frequency.

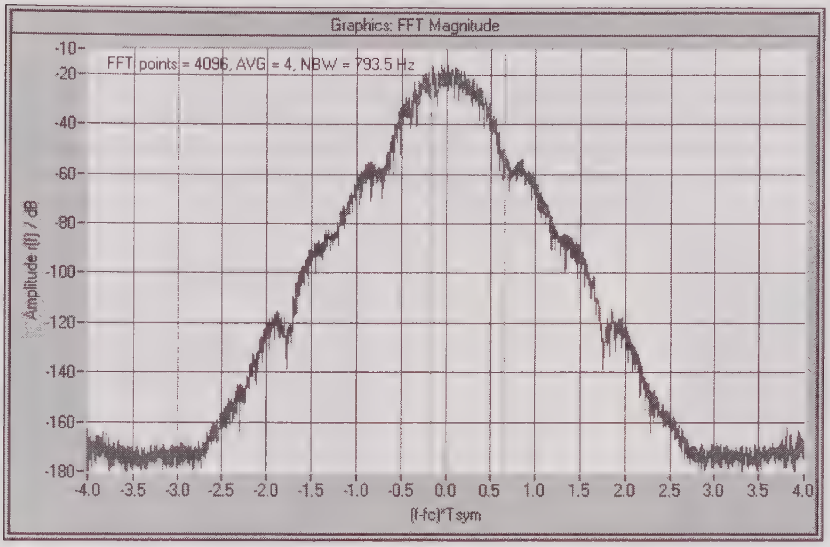


Fig. 5-83 Display of magnitude spectrum

The following FFT info is displayed in the upper left corner of all FFT graphs: FFT points = 4096, AVG = 4, NBW = 793.5 Hz.

This information includes the number of IQ value pairs used for the calculation of a (partial) FFT (FFT points), the number of sub-spectra to be averaged (AVG) and the so-called noise bandwidth (Noise Bandwith NBW). The noise bandwidth results from the frequency spacing of the FFT lines and a correction factor, which depends on the FFT window function.

5.20.3.10 Phase Spectrum

With **FFT Phase** selected, the phase of the displayed spectrum is displayed versus frequency. The spectrum is calculated as described for magnitude display. The same parameters can be selected.

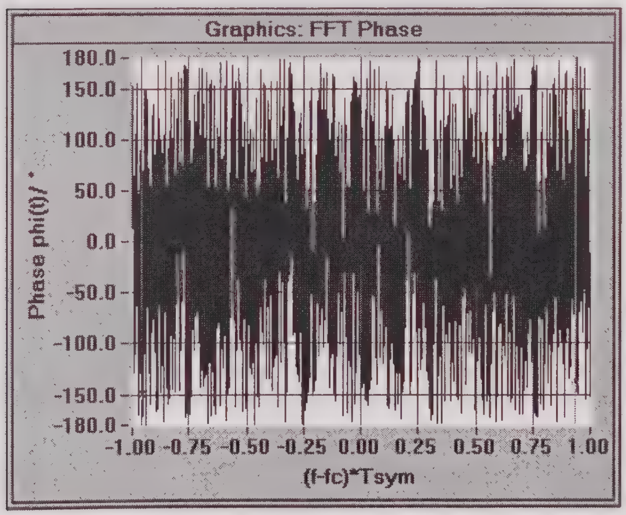


Fig. 5-84 Display of phase spectrum

5.20.3.11 Group Delay Spectrum

With **FFT GD** selected, the group delay is displayed as a function of frequency. The spectrum required for calculating this parameter is calculated in the same way as the magnitude spectrum. The same parameters can be selected. An additional delay can be set in the **FFT Delay** field for the group delay display. A value between 0 and 4096 T_{symbol} can be set. This parameter can be used, for instance, to eliminate constant delays when investigating bandpass filters.

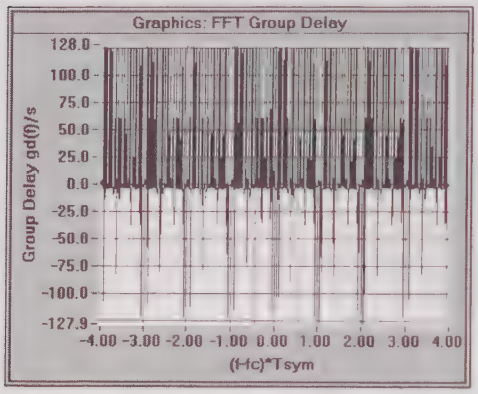


Fig. 5-85 Display of group delay spectrum

5.20.4 Printout of Graphics Display

The current display in the Graphics panel can be printed out with WinIQSIM. For this function the menu item **Graphics: Print** or the respective icon in the toolbar of the main panel can be used. Printing is only possible when the Graphics panel is displayed. Upon selection of the print function, the control elements of the Graphics panel disappear as the graphs should be printed without the buttons. An action window labelled **Print Preview** is displayed in addition.

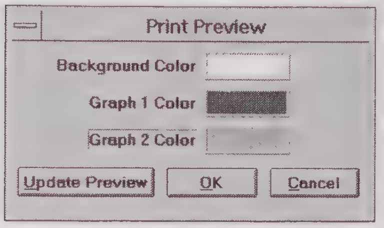
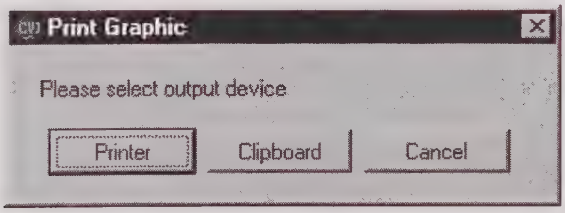


Fig. 5-86 Print Preview panel

In this panel the colours in the Graphics panel can be changed for printing. The black background is very convenient for the screen display of graphs but for hardcopies a white background is much better (alone for the reason of toner user). The background colour of the graphs and the trace colours can therefore be changed in the Print Preview panel. The change can be made in the fields **Background Color**, **Graph 1 Color** and **Graph 2 Color.** The Graph 2 Color field is only active when a format with two graphs has been selected. Selecting a colour is described in section 5.20.2 (click on the field with the left mouse key and select a colour with the mouse key held down).

After the selection, the **Update Preview** button can be pressed. The Graphics panel is displayed with the selected colours. If you are not satisfied with the result, other colours may be chosen.

Printing can be aborted with the **Cancel** button. The Print Preview panel disappears and the Graphics panel is displayed again with its original form and colours.
The selected colours are accepted with the **OK** button. The Print Preview panel is closed and the following dialog box is opened.



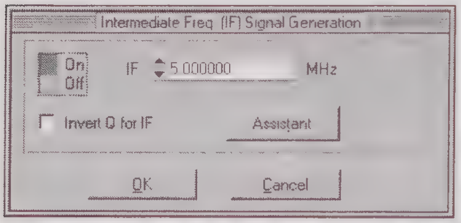
Please select output device

Fig. 5-87 Print Graphic dialog

Selection of Clipboard copies the graph into the clipboard. In this way the graph can easily be inserted into documents or test reports. With the Printer button, a **Print** panel with printer setting fields is opened. Here the printer can be configured before printout is started. Normally, the settings made by WinIQSIM are adequate. Printout can be started with OK or aborted with Cancel. The Print panel disappears and the Graphics panel is displayed again in its usual form and colours.

5.21 IF Signal Generation

Many signal generators are provided with IF inputs. In WinIQSIM, a single-channel IF signal can be generated from the calculated two-channel baseband signal in the **Intermediate Frequency (IF) Signal Generation** panel. The panel can be opened via the IF Generation block in the block diagram or via the IF Signal Generation item in the Modulation menu. IF signal generation is only active when the signal is transferred to AMIQ (or to a file).
The IF signal is output on the I-channel of the AMIQ, the output signal of the Q-channel is zero for IF signals.



Intermediate Freq (IF) Signal Generation

● On
○ Off

IF 5.000000 MHz

☐ Invert Q for IF

Fig. 5-88 Intermediate Frequency (IF) Signal Generation panel.

In this panel IF signal generation can be switched on and off. The IF can be set as required in the range 0.01 MHz to 25 MHz in the **IF** field.

To be able to calculate an error-free IF signal, the selected IF should be higher than half the sampling rate f_{sample}. The IF signal does not contain negative frequency components. The current sampling rate is indicated in the status line. If the above conditions are violated during the setting of the IF, a respective warning is output. If desired by the user, the IF signal is calculated even if conditions are not met. As the IF is too low in this case, this may cause signal errors.

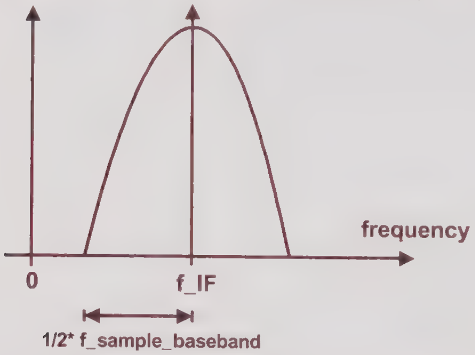


Fig. 5-89 Explanation of the condition for the IF

The IF signal is calculated according to the following formula:

$$s_{ZF}(t) = \mathrm{Re}\left\{\left(i(t) + j \cdot q(t)\right) \cdot e^{j2\pi f_{ZF} t}\right\}$$

A real IF signal is obtained from the complex baseband signal. It is generated with the aid of a fixed oversampling factor of 4, relative to the respective IF. The obtained sampling rate corresponds to four times the IF. Since this considerably simplifies the exponent function of the above equation, calculation of the IF signal is easy.

For this calculation the in-phase and quadrature components of the baseband signal must first be converted to the new sampling rate. This is done by means of an internal resampler.

Invert Q for IF

Upon calculation of the IF signal, the I/Q modulation of the baseband signal is performed at the IF. Unfortunately there is no worldwide uniform definition of an I/Q modulator. For instance, the I/Q modulator defined by the IS2000 (CDMA2000) standard differs from that of WinIQSIM and SMIQ.

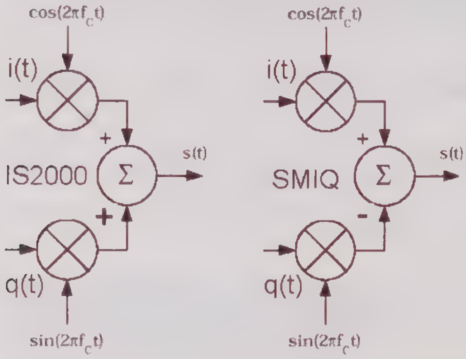


Fig. 5-1 Definition of I/Q modulator in IS2000 and WinIQSIM/SMIQ

As defined by IS2000, the IF (or RF) signal s(t) is obtained from the baseband I/Q signal as follows:

$$s(t) = i(t)\cos(2\pi f_c t) + q(t)\sin(2\pi f_c t)$$

The following definition is used in WinIQSIM and SMIQ.

$$s(t) = i(t)\cos(2\pi f_c t) - q(t)\sin(2\pi f_c t)$$

To enable an I/Q demodulator defined to IS2000 to cope with an IF signal generated by WinIQSIM, the following has to be observed:

- **Generation of IF signals with WinIQSIM and AMIQ**
  To be compatible with the IS2000 I/Q modulator definition, the **Inverted Q for IF** parameter in the IF Generation menu of WinIQSIM must be active.

The **Inverted Q for IF** parameter then inverts the Q component of the baseband signal before the IF signal is calculated. The IF signal can thus be individually adapted to your I/Q modulator/demodulator model.

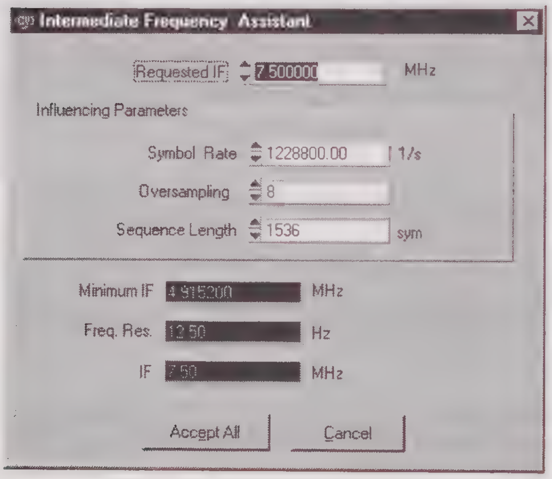
5.21.1 The Assistent Function for Determining the IF

If an IF signal is to be generated from an IQ signal, certain conditions of the IQ signal and the IF must be fulfilled to generate a precision signal. In particular at the wrap around point, ie the point at which the AMIQ output signal changes from the end to the start of the signal, there may otherwise be amplitude differences causing unwanted spikes.

The time period of the IQ signal must be equivalent to an integer multiple of the oscillation period with the intermediate frequency.

$t_{IQ-Signal} = n \cdot \frac{1}{f_{ZF}}$ $\quad n \in N^{+}$ with the time period of the IQ signal being obtained as the ratio of sequence length and symbol rate.

In order to solve this wrap around problem, the assistent function has been integrated which can be activated via the **Assistent button in the Offset panel. After actuating this button, the following modal dialog window is opened.**



Requested IF 7.500000 MHz

Symbol Rate 1228800.00 1/s

Oversampling 8

Sequence Length 1536 sym

Minimum IF 4.915200 MHz

Freq. Res. 12.50 Hz

IF 7.50 MHz

Fig. 5-90 Assistant function IF

The desired IF can be entered in the **Requested Intermediate Frequency field. Please note that only a range between** 0.01 MHz and 25 MHz can be selected. The minimum IF required is entered in the **Minimum IF** field. The modulation parameters influencing the IF setting are entered in the **Influencing Parameters** field. The influencing parameters can be varied in this field to determine the IF that does not cause any wrap around problems (**IF** field). The resolution for varying the IF without problems is stated in the Frequency Resolution field. WinIQSIM automatically selects an IF that causes no problems.
The frequency resolution is defined as:

$f_{resol} = \frac{f_{symbol}}{Sequenzlänge}$, ie as the ratio of the symbol rate of the IQ signal and the sequence length in symbols. The longer the IQ sequence, the more accurate is the setting of an IF without wrap around problems.

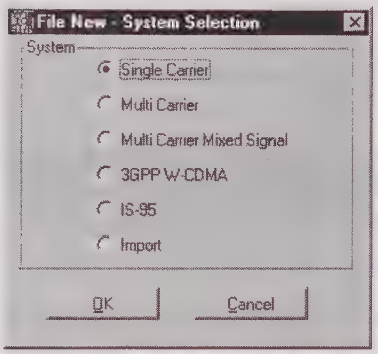
If the panel is closed with the **Accept All button, all set parameters are accepted whereas with the Cancel** button all settings are discarded.

5.22 File Menu

This section describes the File menu of the main WinIQSIM panel. In addition to the standard submenus New, Open, Save As and Exit, WinIQSIM provides the items Save for Add and Show Report. A detailed description of the submenus is given in the following.

5.22.1 New

Based on the default settings made by WinIQSIM (factory settings), a new signal can be configured in this submenu. To this end the **File New - System Selection** panel is opened.



File New - System Selection

System

● Single Carrier
○ Multi Carrier
○ Multi Carrier Mixed Signal
○ 3GPP W-CDMA
○ IS-95
○ Import

Fig. 5-91 File New - System Selection panel

In this panel the system can be selected for which a new signal configuration should be created: Single Carrier, Multicarrier, 3 GPP W-CDMA or IS-95. The currently selected system is displayed in the panel. With **Cancel** the selection is aborted and the main panel is displayed again. With **OK** the selected system is accepted. The System Selection panel is closed. The preset default parameters are loaded for the new system and the main panel with the block diagram of the selected system is displayed. Presettings are briefly described below:

Presettings for Single Carrier

- **Data Source**: PRBS 9
- **Modulation**: QPSK, Reference Level 0 dB, Coding None, Symbol Rate 1000.00 1/s, Sequence Length 200 sym, Filter Rect, Si Compensation Off, Window Function Rect, Impulse Length 8, Oversampling Auto, Baseband Impulse Auto
- **Impairments:** All impairments of the block diagram are OFF. Neutral values are set in the impairment panels.
- **Graphics:** Format i(t), q(t), Autoscaling ON for all axes

Presettings for Multicarrier

- **Data Source**: PRBS 9 for all four data sources
- **Carrier Settings**: Number of Carriers 9, Spacing 2.0 kHz, Optimize Phase ON, Different start values for PRBS OFF, Carrier 4: State ON, Power 0 dB, Modulation ON, Data PRBS; all other carriers: State ON, Power 0 dB, Modulation OFF
- **Modulation**: QPSK, Reference Level 0 dB, Coding None, Symbol Rate 1000.00 1/s, Sequence Length 200 sym, Filter Root Cosine, $\alpha = 0.35$, Si Compensation Off, Window Function Rect, Impulse Length 8, Oversampling Auto, Baseband Impulse Auto

- **Impairments:** All impairments of the block diagram are OFF. Neutral values are set in all the impairment panels.
- **Graphics:** Format FFT Magnitude, FFT Window Hanning, FFT Average 2, Autoscaling ON for all axes , Freq/Time Absolute

Presettings 3 GPP W-CDMA

- **General Settings**: Forward Link, 4.096 Mchips/s, 16 Slots
- **Data Source**: all four data sources PRBS 9

Forward Link

- **Channel Configuration:** BS 1 with 4DPCH, Short Codes 0, 32, 64, 96, 32 kSymbols/s, Power 0dB
- **Filtering**: Filter Root Cosine, α = 0,22, Window Function Rect, Oversampling Auto, Impulse Length 32, Baseband Impulse Dirac
- **Impairments**: All impairments of the block diagram are OFF. Neutral values are set in all the impairment panels.
- **Graphics**: Format FFT Magnitude, FFT Window Hanning, FFT Average 4, Autoscaling ON for all axes, Freq/Time Absolute

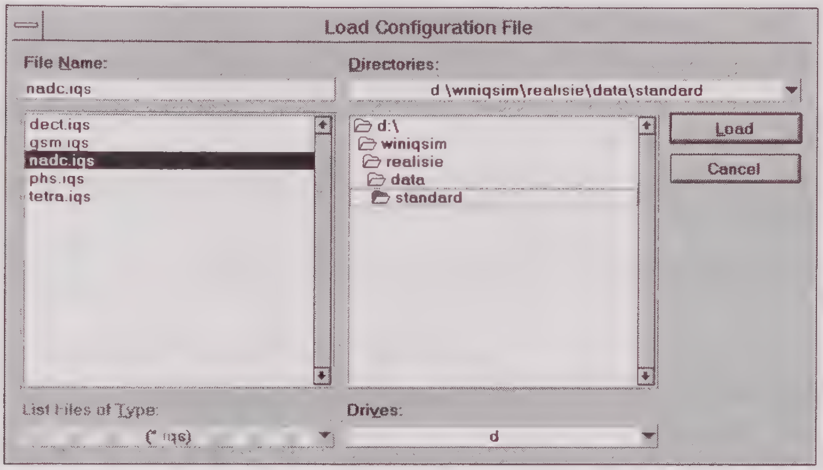
Presettings IS-95

- **General Settings**: Forward Link, 1,2288 Mchips/s, 1536 Symbols
- **Data Source**: all four data sources PRBS 9
- **Channel Configuration:** Base station 1: Pilot, Traffic Walsh 1 and Sync Channel active, power 0 dB, -6 dB, -3 dB
- **Filtering**: Filter Root Cosine, α = 0,20, Window Function Rect, Oversampling Auto, Impulse Length 32, Baseband Impulse Dirac
- **Impairments**: All impairments of the block diagram are OFF. Neutral values are set in all the impairment panels.
- **Graphics**: Format FFT Magnitude, FFT Window Hanning, FFT Average 4, Autoscaling ON for all axes, Freq/Time Absolute

The File New submenu can also be opened with the icon in the toolbar.

5.22.2 Open

Selecting this item opens a file selection window. A configuration file with the extension *.**iqs** (for IQSIM) can be selected. The selected file is loaded with the Load button. The procedure can be aborted with **Cancel**.



Load Configuration File

File Name: nadc.iqs

Directories: d:\winiqsim\realisie\data\standard

List Files of Type: (*.iqs)

Drives: d

Fig. 5-92 File selection window

In addition to the parameters determining the signal configuration, also the sizes and the positions of the panels are loaded. One of the many supplied configuration files can be loaded permitting simple and rapid adaptation to your application. Or a stored, user-defined configuration can be loaded and modified. This submenu can also be opened with an icon in the toolbar.

5.22.3 Save As

Selecting this item opens a file selection window. The configuration set by WinIQSIM can be stored in a configuration file with the extension *.**iqs** (for IQSIM). When the Save button is pressed the configuration is stored in the selected file. The procedure can be aborted with **Cancel**.

In addition to the parameters determining the signal configuration, also the size and position of the panels and a list of currently displayed panels are stored. Thus operation can be continued any time after loading the configuration file.

This submenu can also be called by means of an icon in the toolbar.

5.22.4 Save for Add

Under this menu item, the current I/Q signal can be stored in an internal format for superposition onto a signal later on. A selection window is opened where a file with the extension *.**ibn** can be specified for storing the I/Q signal.

However, a few considerations have to be made before the signals is stored.

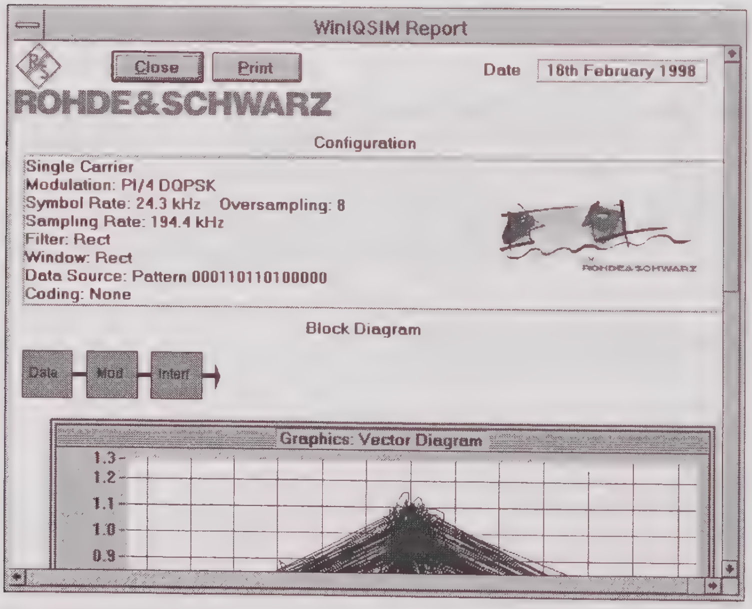
- What signal should the stored file be added to?
- What will the sampling rate ratio be like? (The sampling rate of the stored signal must not exceed that of the signal to which it should be added.)
- What about the ratio of signal periods? To obtain useful results after the addition, the signal to be added should have the same length.

Other aspects of this subject are given in section 5.16.3, which describes signal addition.

5.22.5 Show Report

Under this menu item a report page is generated showing the current graph, the main signal parameters and all active components of the block diagram. This page can then be printed and used for documentation.

On selection of this menu item, the Print Preview panel is displayed which has already been described in connection with the Print Graphics menu (section 5.20.4). In this panel the background colour and the colour of your graphs can be chosen (see section 5.20.4). When the selection is completed, the WinIQSIM Report panel is displayed. The panel comprises a Configuration window, a Block Diagram and a Graphics display window.



Date 18th February 1998

Configuration

Single Carrier
Modulation: PI/4 DQPSK
Symbol Rate: 24.3 kHz Oversampling: 8
Sampling Rate: 194.4 kHz
Filter: Rect
Window: Rect
Data Source: Pattern 000110110100000
Coding: None

Fig. 5-93 Report panel

Configuration

The current system is indicated in the first line of this window. The main parameters, which depend on the selected system, are indicated in the lines below. The following signal parameters are listed for the different systems:

Configuration Parameters for Single Carrier

- Type of modulation
- Symbol rate and oversampling
- Sampling rate
- Baseband filter with filter parameters
- Window function with window parameters
- Data source
- Coding

Configuration Parameters for Multicarrier

- Number of carriers and carrier spacing
- Type of modulation
- Symbol rate and oversampling
- Sampling rate
- Baseband filter with filter parameters
- Window function with window parameters
- Configuration of data sources 0, 1, 2, separated by a vertical line

Configuration Parameters 3 GPP W-CDMA

- Chip rate and spreading factor
- Symbol rate and oversampling
- Sampling rate
- Baseband filter with filter parameters
- Window function with window parameters
- Configuration of data sources 0, 1, 2, separated by a vertical line
- Sequence length in slots

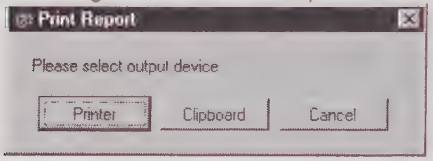
Configuration Parameters IS-95

- Chip rate and spreading factor
- Oversampling
- Sampling rate
- Baseband filter with filter parameters
- Window function with window parameters
- Configuration of data sources 0, 1, 2, separated by a vertical line
- Sequence length in symbols

Block Diagram
A diagram containing all active blocks is displayed in this window. This gives a fast overview of the active impairment blocks. Disabled blocks are not shown in the diagram. For reasons of space the blocks are marked with abbreviated names.

Graphics
In the lower window of the panel the current graph is displayed with the selected colours.

The whole report can be viewed using the horizontal and vertical scrollbars.
If the report should not be printed, close the panel with the **Close** button (at the top of the panel). Pressing the **Print** button opens the following dialog.



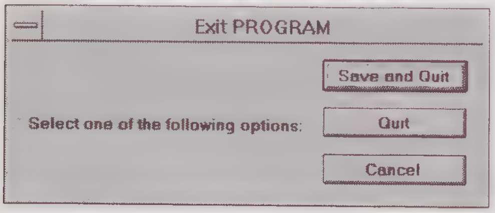
Please select output device

Fig. 5-94 Print Report dialog

Selection of Clipboard copies the report into the clipboard. In this way the report can easily be inserted into documents or test reports. With the Printer button, a **Print** panel with printer-specific settings is opened. In this window the printer can be configured before the printout is started. Normally, the settings made by WinIQSIM are adequate. Printout can be started with OK or aborted with Cancel.

5.22.6 Exit

WinIQSIM can be quit with this menu item and the respective icon in the toolbar. The following selection window is displayed:



Select one of the following options:

Fig. 5-95 Selection window for quitting WinIQSIM

The options **Save and Quit** or **Quit** and **Cancel** can be selected.

Save and Quit: The current configuration can be saved in a file before WinIQSIM is quit. To do so a file selection window is opened same as for Save As.

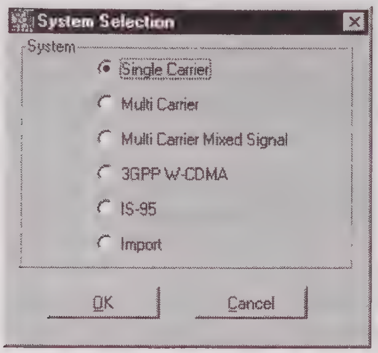
Quit: WinIQSIM is terminated without the current configuration being stored under a specific name.

Cancel: Select this option if you do not wish to quit WinIQSIM. The selection window is closed and the work with WinIQSIM can be continued.

Irrespective of the option selected for terminating WinIQSIM, the settings of the current work session are stored in a internal configuration file. Upon the next start of WinIQSIM these settings will be loaded.

5.23 System Menu

In this menu different systems can be selected. First the **System Selection** panel is opened.



● Single Carrier
○ Multi Carrier
○ Multi Carrier Mixed Signal
○ 3GPP W-CDMA
○ IS-95
○ Import

Fig. 5-96 System Selection panel

In this panel the Single Carrier, Multicarrier, 3 GPP W-CDMA or IS-95 system can be selected. The currently selected system is marked in the panel. When **Cancel** is pressed the procedure is aborted and the main panel is displayed again. With **OK** the system selection is confirmed and the System Selection panel is closed. The last configuration of the new system is loaded. The main panel with the block diagram of the selected system is displayed. All panels of this system that were active in the last session are also displayed. Thus operation can be easily continued with the last settings after a system change.

5.24 Progress of Signal Calculation

After a trigger of an I/Q signal calculation, for instance for a graphics display or a transfer to the AMIQ, the progress of the calculation is continually indicated by messages and progress indication bars.

Before the actual calculation is started, the conditions required by the I/Q modulation source AMIQ are checked. This means that the calculated signal must not be longer than 4 million samples. The total sampling rate of the signal must not exceed 100 MHz. Make sure that the IF has at least half the value of the sampling rate for the calculation of an IF signal.

If one or several of these conditions are not met, a respective message is output. It may happen that a calculation is not performed. In this case the signal parameters can be changed and calculation triggered again.

Single Carrier
Before starting the calculation the program provides the necessary dynamic memory. If the available memory is not sufficient, a respective message is output and measures are suggested for a remedy. The calculation is stopped.
If sufficient memory can be provided, Preparing Calculation is displayed. While this message is displayed, the internal filters and calculation procedures are prepared. If PRBS is used as a data source, the message Preparing PRBS source for settling is displayed. The PRBS generator must be set to the correct state to ensure internal settling. This may take up some time in the case of long PRBS sequences and great sequence lengths. The progress bar continually informs on the status of the calculation.
With these preparations terminated, the Preparing Calculation message is cleared and a progress bar labelled **Calculating I and Q values** is displayed.

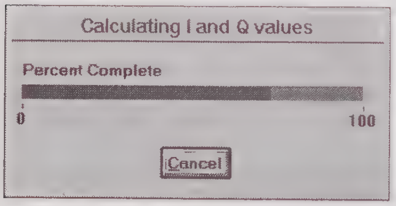
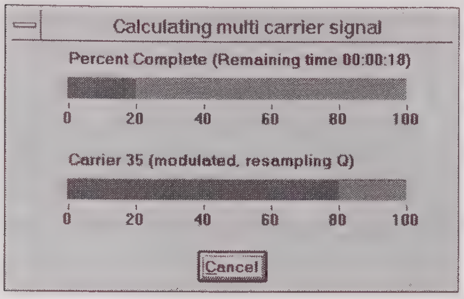


Fig. 5-97 Progress bar for calculation of I and Q values

Calculation of the I/Q output signal is started. A red bar informs the user on the progress of the calculations. To abort the calculation press the Cancel button in the progress window. The calculation is stopped after confirming a query.
Other windows may be displayed depending on the set signal configuration. Resampling may be required, for instance, when a signal is added (Interferer: Add Signal). A progress bar labelled **Resampling I/Q for Add Signal** is displayed in this case.

Multicarrier
Before starting the calculation the program provides the necessary dynamic memory. If the available memory is not sufficient, a respective message is output and measures are suggested for a remedy. The calculation is stopped.
If sufficient memory is available, the two progress bars shown below are displayed in a window labelled **Calculating multicarrier signal**.



Calculating multi carrier signal

Percent Complete (Remaining time 00:00:18)

Carrier 35 (modulated, resampling Q)

Fig. 5-98 Progress bars for multicarrier

In the lower part of the window, the currently processed carrier and the progress of the internally performed calculation step are displayed. The baseband signal must first be calculated for each modulated carrier (display: **Carrier 0 (modulated, baseband signal)**). Then the baseband signal of the carrier has to be converted to the total sampling rate (display: **Carrier 0 (modulated, resampling I/Q)**). After this, the resampled baseband signal must be mixed to its carrier frequency (display: **Carrier 0 (mixing)**). In the worst case these steps have to be performed for all carriers. If many of the modulated carriers use the same data source, calculation can be considerably simplified. However, if the option **Different start values for PRBS** is switched on, all modulated carriers using the PRBS data source have to be calculated separately. Shortly before calculation of the baseband signals of the modulated carriers is started, the progress bars **Preparing Calculation** and, if necessary, **Preparing PRBS source for settling** are displayed same as with the single-carrier mode.
The bar in the upper part of the progress indication panel informs on the total progress of the calculation. After the first calculation steps have been performed, the remaining calculation time is estimated. This remaining time is indicated in the headline of the total progress bar (**Percent Complete (Remaining Time 00: 05: 24)**). The estimated time is specified in **hours: minutes: seconds**. A new evaluation of the remaining time is made each time the total progress bar is updated. The specified time is not an absolute value. It should only give a rough idea of the time left for the calculation. The remaining calculation time increases if further applications are started during the calculation or when the PC starts to swap memory contents to the hard disk.

To abort the calculation press the Cancel button in the progress window. After a confirmation query the calculation is stopped.

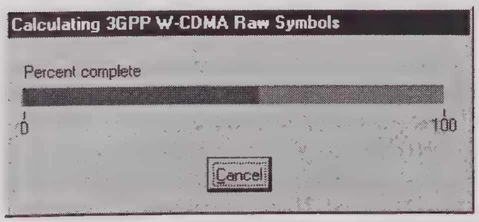
Other windows may be displayed as required by the set signal configuration. So resampling may have to be performed, for instance, when a signal is added (Interferer: Add Signal). In this case a progress bar labelled **Resampling I/Q for Add Signal** is displayed.

3 GPP W-CDMA

Before starting the calculation the program provides the necessary dynamic memory. If the available memory is not sufficient, a respective message is output and measures are suggested for a remedy. The calculation is stopped.
If sufficient memory is available, the signal calculation is started.

.

A **3 GPP** W-CDMA signal is calculated in two big steps. In the first step, the so-called raw symbols are determined. For this purpose, the partial signals of the individual code channels are spread and summed up according to the calculation regulations of **3 GPP** W-CDMA.
Meanwhile, the progress bars shown below is displayed in a window labelled **Calculating 3 GPP W-CDMA Raw Symbols**.



Calculating 3GPP W-CDMA Raw Symbols

Percent complete

Fig. 5-99 Progress bars **3 GPP** W-CDMA

In the lower part of the window, the currently processed channel of the **3 GPP** W-CDMA system is displayed. The bar in the upper part of the progress indication panel informs you on the total progress of the calculation.

The second step includes the baseband filtering and the superiposition of the W-DCMA signal. The progress window Calculating I and Q values already known from the single carrier system appears here.

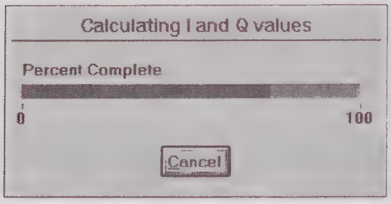


Fig. 5-100 Progress window for the second step of **3 GPP** W-CDMA signal calculation

To abort the calculation press the Cancel button in the progress window. After a confirmation query the calculation is stopped.

Other windows may be displayed as required by the set signal configuration. Resampling may have to be performed, for instance, when a signal is added (Interferer: Add Signal). In this case a progress bar labelled **Resampling I/Q for Add Signal is displayed**.

IS-95

Before starting the calculation the program provides the necessary dynamic memory. If the available memory is not sufficient, a respective message is output and measures are suggested for a remedy. The calculation is stopped.

If sufficient memory is available, the signal calculation is started. An IS-95 signal is calculated in two large steps. In the first step, the so-called raw symbols are determined. For this purpose, the partial signals of the individual code channels are spread and summed up according to the calculation regulations of IS-95.

Meanwhile, the two progress bars shown below are displayed in a window labelled **Calculating IS-95 Raw Symbols**.

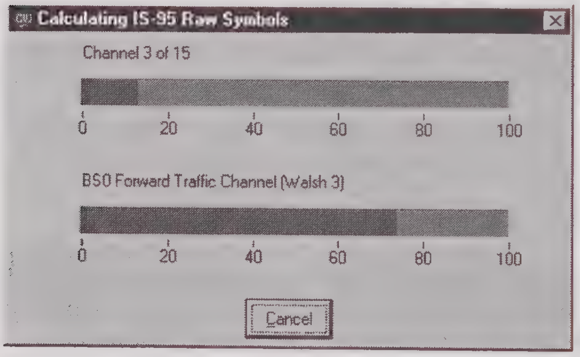

Calculating IS-95 Raw Symbols
Channel 3 of 15
0
20
40
60
80
100
BS0 Forward Traffic Channel (Walsh 3)
0
20
40
60
80
100
Cancel

Fig. 5-101 Progress bards IS-95

In the lower part of the window, the currently processed channel, in the forward link the current base station of the IS-95 system are displayed.The display in the upper part of the progress indication panel informs you on the total progress of the calculation.

The second step includes the baseband filtering and the superposition of the IS-95 signal. The progress window Calculating I and Q values already known from the single carrier system appears here.

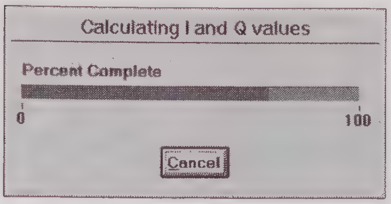


Fig. 5-102 Progress window for the second step of the IS-95 signal calculation

To abort the calculation press the Cancel button in the progress window. After a confirmation query the calculation is stopped.

Other windows may be displayed as required by the set signal configuration. So resampling may have to be performed, for instance, when a signal is added (Interferer: Add Signal). In this case a progress bar labelled **Resampling I/Q for Add Signal is displayed**.

Multicarrier Mixed Signal

Before starting the calculation the program provides the necessary dynamic memory. If the available memory is not sufficient, a message is output and measures are suggested for a remedy. The calculation is stopped.

If sufficient memory is available, the two progress bars shown below are displayed in a window labelled **Calculating Multi Carrier Mixed Signal**.

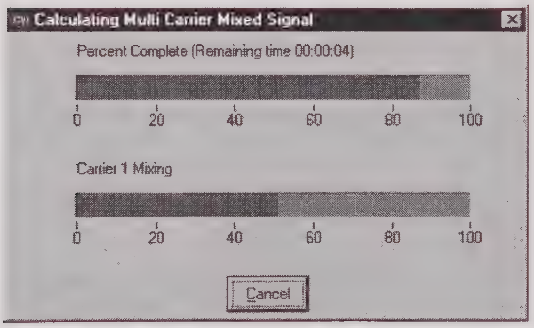

Calculating Multi Carrier Mixed Signal
Percent Complete (Remaining time 00:00:04)
0
20
40
60
80
100
Carrier 1 Mixing
0
20
40
60
80
100
Cancel

Fig. 5-103 Progress bar window Multi Carrier Mixed Signal

The lower bar indicates the carrier currently processed and the internal calculation step together with its progress status. For each carrier, the baseband signal is adjusted to the total sampling rate (display: **Carrier 0 (resampling I/Q)**). Then the resampled baseband signal is mixed to its carrier frequency (display: **Carrier 0 (mixing)**). In the worst case, these steps have to be performed for all carriers. If several carriers use the same IQ signal file, calculation becomes much simpler.

The upper bar indicates the progress status of the calculation procedure as a whole. Once the first few calculation steps have been performed, an estimation is made of the remaining time required for the calculation. This estimated value is shown in the title field above the total progress bar (**Percent Complete (Remaining Time 00: 05: 24)**) expressed in **hours: minutes: seconds** format. The remaining time is estimated anew each time the total progress bar is updated. The remaining time indicated is not an absolute value, but is intended to give an idea of how long the calculating procedure will take. It may take longer than indicated especially if you start new applications while the calculation is being performed, or if your PC starts exporting memory contents to the harddisk (swapping).

If you wish to cancel the calculation, press the Cancel button in the progress window. Upon confirming that you really wish to cancel the operation, the calculation will be stopped.

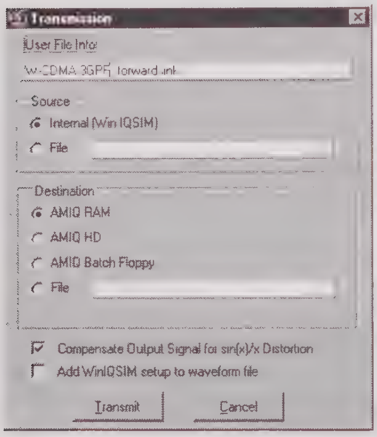
5.25 AMIQ Menu

The AMIQ menu comprises all functions required for transmitting I/Q data to the AMIQ, remote control of AMIQ and for configuring the transmission interface. The individual submenus and associated setting panels are described in the following.

5.25.1 Transmission Panel

The Transmission panel is the interface for the transmission of calculated I/Q data to AMIQ. As an alternative, data can be directly transmitted to AMIQ via the GPIB/IEEE 488.2 bus, the RS-232 interface or via floppies.

The Transmission panel comprises three windows. In the first a comment on the current I/Q data stream can be entered. This comment can subsequently be read out of AMIQ for simplifying selection and management of waveform files. In the second window a selection can be made whether the I/Q signal generated by WinIQSIM or an I/Q waveform file stored on the hard disk of your PC should be transmitted. In the last panel the destination of the transmission is selected. The waveform can be transmitted to the output RAM or hard disk of AMIQ as well as stored on floppies or on the hard disk of your PC.



User File Info: W-CDMA 3GPP forward link

Source
- ● Internal (Win IQSIM)
- ○ File

Destination
- ● AMIQ RAM
- ○ AMIQ HD
- ○ AMIQ Batch Floppy
- ○ File

☑ Compensate Output Signal for sin(x)/x Distortion

☐ Add WinIQSIM setup to waveform file

Fig.: 5-104 Transmission panel

User File Info: In this field a comment of up to 79 characters on the current I/Q signal can be entered. This comment is stored together with the I/Q data and can subsequently be read out of AMIQ to simplify selection and management of waveform files.

Source: In this window a selection can be made whether the I/Q signal defined by WinIQSIM (**Internal**) or a signal (**File**) previously stored on the hard disk of your PC should be transmitted. In the File selection field the currently selected source file is displayed. To select another source file click into the field with the left mouse key. A file selection window is opened where a file with the extension ***.wv** (waveform) can be selected for transmission.

Destination: In this window the destination of the transmission is set. The selected I/Q signal can be directly transmitted to the output RAM of AMIQ (**AMIQ RAM**), or a path on the AMIQ hard disk (**AMIQ HD**) can be selected. If AMIQ batch floppy is selected as the destination, the waveform is stored on one floppy disk in a format that can then be loaded via the AMIQ disk drive. A calculated signal (**File**) can also be stored on the hard disk of your PC for later transmission to AMIQ. The currently selected destination file is indicated in the File selection field. Here a file with the extension ***.wv** (waveform) can be selected where the signal should be stored. This procedure is limited to waveforms storable on floppy disk.

Compensate Output Signal for sin(x)/x Distortion:
If the IQ signal transferred to AMIQ is output by AMIQ as an analog signal (ie not via option AMIQ-B3 “Digital IQ Outputs“), the signal is sin(x)/x-distorted due to the D/A converters in AMIQ. If the option **Compensate Output Signal for sin(x)/x Distortion** is active, WinIQSIM corrects this distortion automatically when IQ sequences are transferred into AMIQ.

This option should be activated only if the IQ signal in AMIQ is not output via the digital outputs (option AMIQ-B3).

Add WinIQSIM Setup to Waveform File:
With this option activated, the current setup of WinIQSIM (*.iqs file) is transferred to AMIQ together with the IQ data. This setup is then permanently coupled with the waveform in AMIQ but can be read out of AMIQ any time (see section 5.25.7) so that the WinIQSIM parameters are again available separately from the associated IQ waveform. It can be seen in this way how the IQ signal was generated, and the original IQ signal can be varied by editing parameters.
It should be noted that transferring IQ data together with the setup will expand waveform files in AMIQ by up to 200 Kbytes, thus limiting the number of waveforms that can be stored on the hard disk of AMIQ. The option should for this reason not be permanently activated.

IQ swap:
Unfortunately there is no worldwide uniform definition of an I/Q modulator. For instance, the I/Q modulator defined by the IS2000 (CDMA2000) standard differs from that of WinIQSIM and SMIQ.

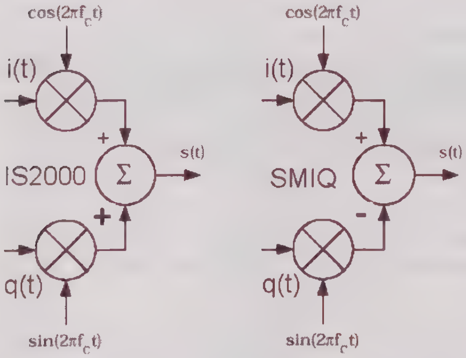


Fig. 5**Fehler! Es wurde kein Formatvorlagenname vergeben.**-1 Definition of I/Q modulator in IS2000 and WinIQSIM/SMIQ

As defined by IS2000, the IF (or RF) signal s(t) is obtained from the baseband I/Q signal as follows:

$$s(t) = i(t)\cos(2\pi f_c t) + q(t)\sin(2\pi f_c t)$$

The following definition is used in WinIQSIM and SMIQ:

$$s(t) = i(t)\cos(2\pi f_c t) - q(t)\sin(2\pi f_c t)$$

To enable an I/Q demodulator defined to IS2000 to cope with an IF signal generated by SMIQ, the following has to be observed:

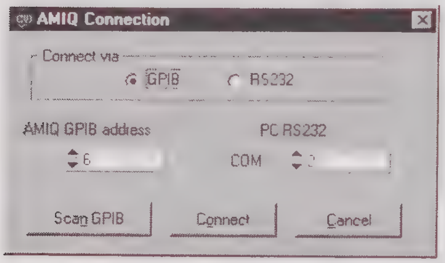
- **Generation of RF signals with SMIQ**
  The I/Q SWAP parameter in the VECTOR MOD menu must be on to be compatible with the IS2000 I/Q modulator definition.

The **I/Q swap** parameter effects that a note is made in the I/Q signal file transferred to AMIQ whether I/Q swap should be used or not. The RF signal can thus be individually adapted to your I/Q modulator/demodulator model. If desired, WinIQSIM automatically evaluates this signal information and configures SMIQ accordingly, see also section 5.25.12.

5.25.1.1 Signal Transmission

The selected transmission mode is started with the **Transmit** button.
The transmission procedure for the various combinations of source and destination is described below.

Source Internal ⇒ AMIQ RAM
The signal configured by WinIQSIM is directly transmitted to the output RAM of AMIQ. In a first step WinIQSIM establishes a connection to AMIQ. If **Automatically retry previous interface** is selected in the **Interface and Transmission Options** panel, an attempt is made to access AMIQ under the address/interface used for the last successful transmission. If this attempt fails or if the option is not selected in the Interface and Transmission Options panel, the following panel is displayed.



Connect via: ● GPIB ○ RS232

AMIQ GPIB address: 6

PC RS232: COM

Fig.:5-105 AMIQ Connection panel

Here the interface (GPIB/IEEE 488.2 or RS-232) and the address for the desired AMIQ connection can be selected. If your AMIQ is connected to the GPIB/IEEE 488.2 bus and you do not know its address, an automatic search for AMIQ can be triggered with the Scan GPIB button.

With the connection to AMIQ established, the I/Q signal is calculated as configured. This step is omitted when the calculation has been performed before, eg for a graphics display.

If signal values are likely to be clipped or the AMIQ overdriven because of the current settings, the **Signal Statistics and Quantization** panel is opened. This panel described in section 5.25.3 provides information on signal statistics and permits to influence the conversion of I/Q values from WinIQSIM to the AMIQ transmission format.

Depending on the signal configuration and the parameters set in the Prepare for AMIQ Lowpass Filter panel (see section 5.25.4), a message of this panel or the whole panel can now be displayed. For details refer to section 5.25.4.

The calculated I/Q values are converted to the AMIQ format (14 bits for I and 14 bits for Q). During conversion the following progress indication window is displayed.

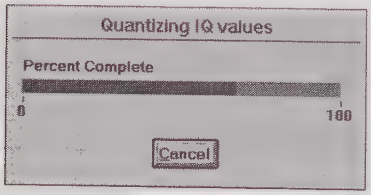


Fig.:5-106 Progress indication for conversion of I/Q values to AMIQ format

After the conversion, the I/Q waveform is transmitted to AMIQ. The window below informs on the progress of transmission.

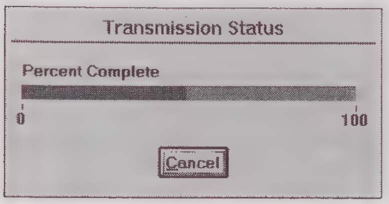
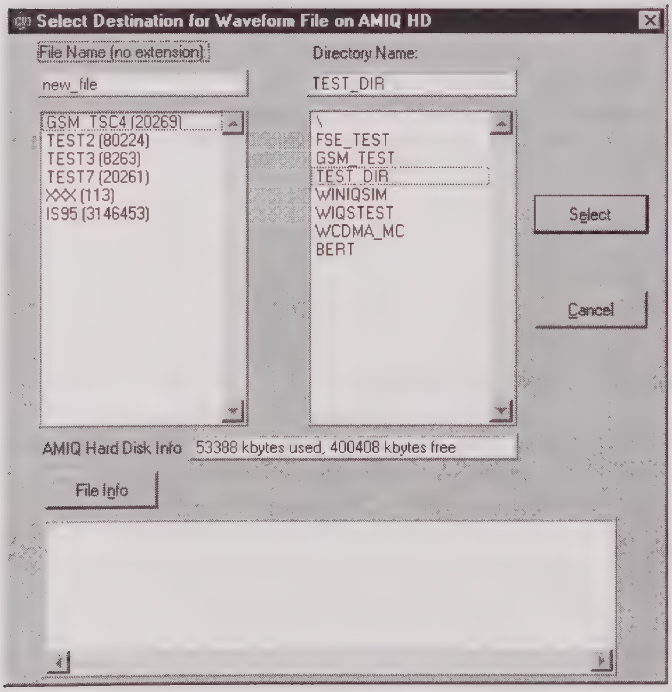


Fig.:5-107 Progress indication for transmission of I/Q values to AMIQ

After all data have been transmitted, correct reception in the AMIQ is checked with the aid of a check sum. If an error is detected, a respective message is entered in the error queue. After the transmission, WinIQSIM reads out the error queue and thus informs the operator on problems, if any. If no error occurred, no message is output.

When the **Automatically load and start waveform after transmission** option has been selected in the **Interface and Transmission Options** panel, the output of the transmitted signal is started in the AMIQ.

Source Internal ⇒ AMIQ HD
The signal configured by WinIQSIM is transmitted to the hard disk of AMIQ.
Same as with **Internal ⇒ AMIQ RAM**, a connection to AMIQ is established first. Then a file selection window is displayed where the destination file on the AMIQ hard disk can be defined.



File Name (no extension): new_file
Directory Name: TEST_DIR

GSM_TSC4 (20269)
TEST2 (80224)
TEST3 (8263)
TEST7 (20261)
XXX (113)
IS95 (3146453)

\
FSE_TEST
GSM_TEST
TEST_DIR
WINIQSIM
WIQSTEST
WCDMA_MC
BERT

AMIQ Hard Disk Info: 53388 kbytes used, 400408 kbytes free

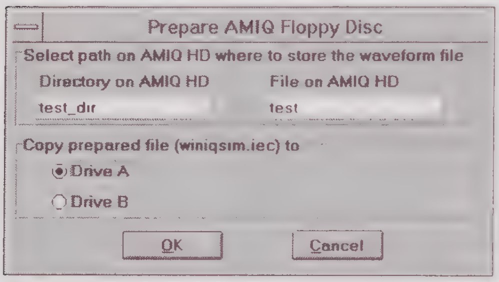
Fig.:5-108 Window for selecting a waveform file on AMIQ hard disk

In this window an AMIQ directory can first be selected with the left mouse key. An existing file can then be selected in this directory or a new file name entered in the **File Name** field (max. eight characters, no file extension). The selection is confirmed with the **Return** key or the **Select** button.

From this point, transmission is the same as described for **Internal ⇒ AMIQ HD** (I/Q signal calculation, conversion to AMIQ format, transmission).

Source Internal ⇒ AMIQ Batch Floppy
The signal configured by WinIQSIM is stored in a special format on one floppy. The information on the file of the AMIQ hard disk on which the signal should be stored, is saved on the floppy together with the signal data. This special format is required for loading a waveform via the AMIQ floppy disk drive.

A respective item (**AMIQ CTRL - SELECT WAVEFORM – EXECUTE BATCH FROM FLOPPY**) is provided in the **AMIQ CTRL** menu of Vector Signal Generator SMIQ for triggering the load process. Pressing the Transmit button opens the following dialog window:


Prepare AMIQ Floppy Disc

Select path on AMIQ HD where to store the waveform file

Directory on AMIQ HD: test_dir

File on AMIQ HD: test

Copy prepared file (winiqsim.iec) to

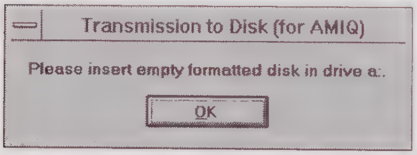
● Drive A

○ Drive B

Fig.:5-109 Selection of path for AMIQ batch floppy

The directory where the waveform file should be stored later on can be specified (max. 8 characters) in the **Directory on AMIQ HD** field. If this directory does not exist, it is created when the batch file is executed. The file name for storing the signal in the specified directory can be entered in the **File on AMIQ HD** field (max. 8 characters, no extension). The drive of your PC to be used for generating the batch floppy(ies) can be selected in the **Copy prepared file (winiqsim.iec) to** field.

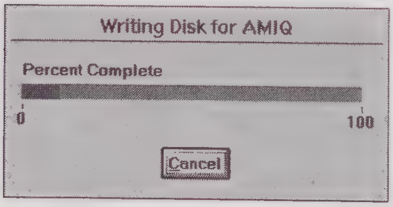
When all these items have been defined, press the OK button to continue transmission. From this point onwards, transmission is as described for **Internal ⇒ AMIQ HD** (I/Q signal calculation, conversion to AMIQ format). With conversion to the AMIQ format completed, one of the following messages is displayed.


Transmission to Disk (for AMIQ)

Please insert empty formatted disk in drive a:.

Fig.:5-110 Message displayed during generation of AMIQ batch floppy

Insert the floppy to the specified drive and acknowledge the displayed message. The signal data are now copied onto the floppy. While data are written onto the floppy the following progress bar is displayed:


Writing Disk for AMIQ

Percent Complete

Fig.:5-111 Progress bar displayed during writing to AMIQ batch floppy

Source Internal ⇒ File
The signal configured by WinIQSIM is stored in a file on the hard disk of your PC.

The file where the signal should be stored can be selected in the field at the right of **File** in the **Destination** window.

Pressing the **Transmit** button starts the calculation of the I/Q signal. If signal values are likely to be clipped or the AMIQ overdriven because of the current settings, the **Signal Statistics and Quantization** panel is opened. This panel described in section 5.25.3 provides information on signal statistics and permits to influence the conversion of I/Q values from WinIQSIM to the AMIQ transmission format.

Depending on the signal configuration and the parameters set in the AMIQ Lowpass Filter prepare panel (see section 5.25.4), a message of this panel or the whole panel can now be displayed. For details refer to section 5.25.4.

The calculated I/Q values are converted to the AMIQ format (14 bits for I and 14 bits for Q).

After the conversion, the I/Q waveform is stored on your PC.

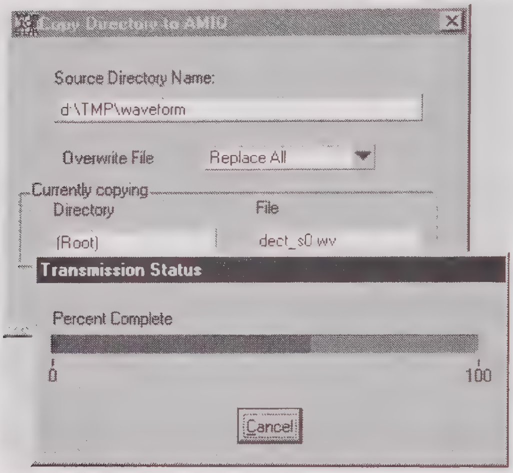
Source File ⇒ AMIQ RAM / Source File ⇒ AMIQ HD / Source File ⇒ AMIQ Batch Floppy / Source File ⇒ File

Transmission from a source file is similar to the procedure described for a transmission from an internal source. The difference is that calculation of the I/Q signal, display of the Signal Statistics and Quantization panel, prepare for AMIQ Lowpass Filter and conversion to the AMIQ format are not required.

The file containing the signal to be transmitted can be selected in the field at the right of **File** in the **Source** window.

5.25.2 Copy Directory

This function allows convenient and fast copying of several files including the directory from the PC to the hard disk of AMIQ. (A similar function for only one file is provided in the AMIQ Transmission panel if -> File is selected as source and -> AMIQ HD as destination.)



Source Directory Name: d:\TMP\waveform

Overwrite File: Replace All

Currently copying

Directory: (Root)

File: dect_s0.wv

Fig.:5-112 Copy Directory to AMQI HD panel

First select in the Copy Directory panel the source directory under Source Directory Name. All files with the extension '.wv' contained in this directory will be transferred to the root directory of AMIQ.

This source directory may also have a subdirectory level. If this is the case, directories with the same name will be generated in AMIQ (provided that the source directory is not empty). Then, all *.wv files from this subdirectory are transmitted from the PC to AMIQ.

Example : *The following files and directories are available on the PC:*
...\mydir\test.wv
..\mydir\test.iqs
..\mydir\nadc\nadc1.wv
..\mydir\nadc\nadc2.wv
..\mydir\nadc\nadc.iqs
..\mydir\nadc\test.wv
..\mydir\gsm\myfile.wv

If 'mydir' is selected as the source directory, the following file structure will be available on AMIQ after execution of the copy function with the Copy button:

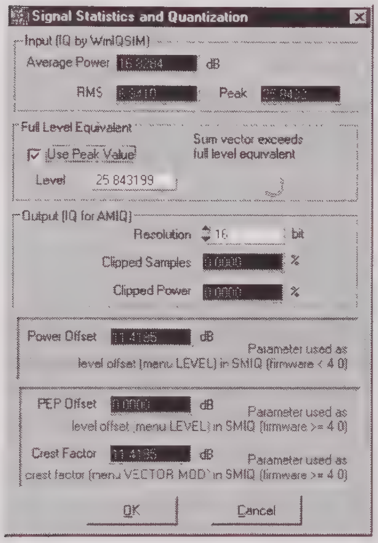
Directory Name	**File Name**
\	test
nadc	nadc1, nadc2, test
gsm	myfile

The Overwrite File selection box is provided for selecting the response of the function in case that a file of the same name already exists in AMIQ. With Replace All selected, all files will be overwritten without any further warning. "Prompt on Replace" opens a box in which overwriting has to be confirmed and Replace Never leaves the existing file as it is.

During the transmission of the files, the file currently copied is indicated in the "Currently copying" fields with the progress bar showing the progress of the copying process.

5.25.3 Signal Statistics and QuantizationPanel

The I/Q signal is calculated by WinIQSIM as a sequence of floating-point numerals. Before the transmission to AMIQ the signal has to be converted to the AMIQ format (14 bits us standard for I and 14 bits us standard for Q). The user can specify an I/Q signal level in WinIQSIM that corresponds to full-scale level in the AMIQ. For determining this signal level, a few statistical parameters of the I/Q signal calculated by WinIQSIM are displayed in the upper window of this panel.


Signal Statistics and Quantization

Input (IQ by WinIQSIM)
Average Power 16.8284 dB
RMS 6.9410 Peak 25.8432

Full Level Equivalent
☑ Use Peak Value
Sum vector exceeds full level equivalent
Level 25.843199

Output (IQ for AMIQ)
Resolution 16 bit
Clipped Samples 0.0000 %
Clipped Power 0.0000 %

Power Offset 11.4185 dB
Parameter used as level offset (menu LEVEL) in SMIQ (firmware < 4.0)

PEP Offset 0.0000 dB
Parameter used as level offset (menu LEVEL) in SMIQ (firmware >= 4.0)

Crest Factor 11.4185 dB
Parameter used as crest factor (menu VECTOR MOD) in SMIQ (firmware >= 4.0)

Fig.:5-113 Signal Statistics and Quantization panel

Input (IQ by WinIQSIM):
The average power, the rms power and the peak power of the I/Q signal are displayed in this window.

Average Power: The average power of the I/Q signal is calculated according to

$$\overline{P} / dB = 10 \cdot \log_{10}\left(\frac{\sum\limits_{n}\left[i^2(n)+q^2(n)\right]}{n}\right)$$, n = number of sampling values

RMS: The rms value of the signal is determined by

$$RMS = \sqrt{\frac{\sum\limits_{n}\left[i^2(n)+q^2(n)\right]}{n}}\ .$$

Peak: The peak value of the sum vector of i(n) and q(n) is determined by

$$peak = \max_{\forall n}\left[\sqrt{i^2(n)+q^2(n)}\right].$$

Full Level Equivalent
The sequences of floating-point numerals produced by WinIQSIM for the I and Q signals have to be converted to the 14-bit format of AMIQ prior to transmission. First the value range of the floating-point numerals in WinIQSIM to be converted into the full-scale range of AMIQ has to be determined. Only ranges that are symmetrical to zero can be selected, eg [-1.5, 1.5]. The diagram below illustrates the conversion.

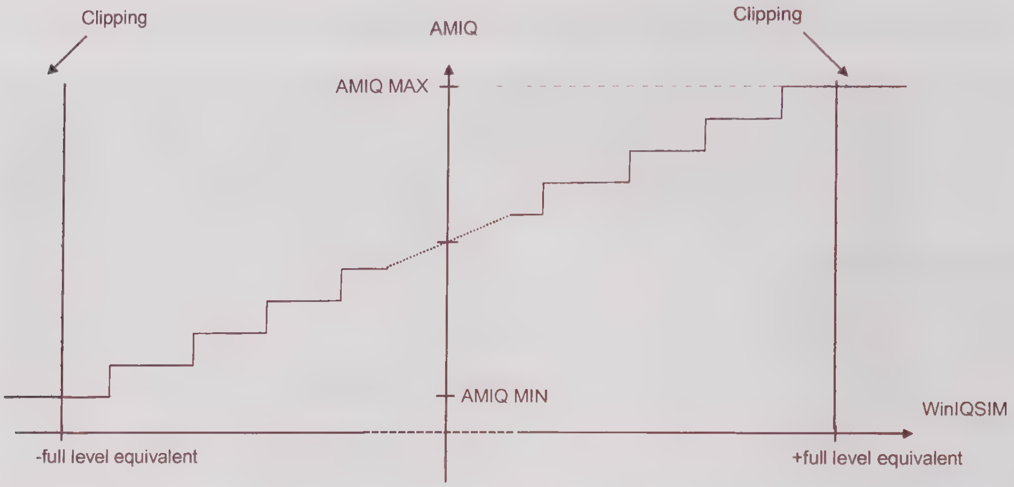


Fig.:5-114 Conversion of I/Q values to AMIQ format

The full-level range is the difference between the **-full level equivalent** and the **+full level equivalent.** All input values below the -full level equivalent are shown as AMIQ MIN (minimum output value of AMIQ), and all values above the +full level equivalent are displayed as AMIQ MAX (maximum output value of AMIQ). When the range is exceeded in this way, **Clipping** .effects will occur. The loss of sampling values and signal power caused by clipping is displayed as a percentage in the **Clipped Samples** and **Clipped Power** fields.

When the **Use Peak Value** , option is selected, the previously calculated maximum value of the sum vector of I and Q is automatically set as full level equivalent. Clipping does not occur. This option should be selected to avoid signal impairments. However, if impairments with large peaks are superimposed on your signal, the use of the peak value as full level equivalent may lead to a very low resolution in the useful signal range as a considerable part of the accuracy is used for the impairment. In this case using a lower level than the peak value may be of advantage. The display of clipped samples and clipped power may help you to find a full level equivalent where only a small part of the sampling values is clipped.

Sum vector exceeds full level equivalent: When the full level equivalent is manually set, ie if the peak value is not used, it may happen that the sum vector of the I and Q signal exceeds the full-level range once or several times. This may not in all cases lead to clipping. This effect shows up particularly well in the case of QPSK modulation. The behaviour is illustrated in the diagram below.

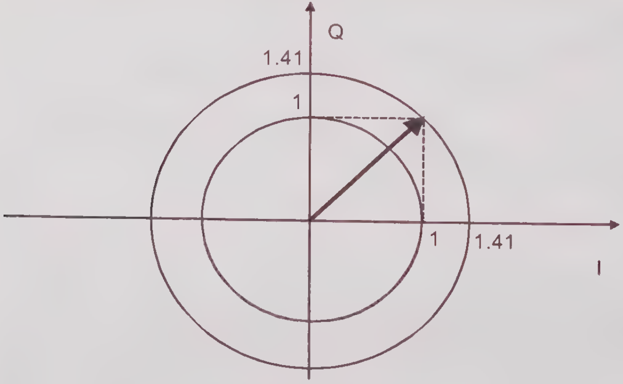
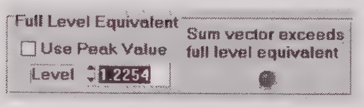


Fig.:5-115 Sum vector with QPSK

The maximum value of the I and Q components is 1.0 but the sum vector may increase by a factor of $\sqrt{2}$. This means that clipping occurs only when the full level equivalent drops below 1.0. The sum vector exceeds the full level equivalent much earlier, however. At first this has no consequences for the

AMIQ output signal, If this signal is applied to the Vector Signal Generator SMIQ, the I/Q modulator may be overdriven (see also section 2.8, Vector Modulation, in the SMIQ manual).

The red **Sum vector exceeds full level equivalent** LED lights up for user information.



Full Level Equivalent
☐ Use Peak Value
Level 1.2254
Sum vector exceeds full level equivalent ●

Fig.:5-116 Risk of SMIQ overdrive

Resolution:
With analog IQ outputs, AMIQ has a standard resolution of 14 bits per sample for I and 14 bits for Q. The Resolution parameter allows values other than the standard resolution to be set. Resolution can be set between 8 and 16 bits. A resolution higher than 14 bits will be effective only with option AMIQ-B3 "Digital IQ Outputs".
WinIQSIM generates the waveform in accordance with the selected resolution with 14 bits (if resolution ≤ 14 bits was selected) or with 16 bits (if resolution > 14 bits was selected, in this case without marker). The selected resolution is stored in the transferred waveform. AMIQ automatically converts the waveform data to the selected resolution before the data are output.
This procedure has the advantage that no bits are "wasted" during data transfer. Resolution can subsequently be changed in AMIQ (see section **Fehler! Verweisquelle konnte nicht gefunden werden.**) by varying a parameter in the range from 8 bits up to the resolution of the transferred waveform (ie 14 bits or 16 bits).

Example:
You have selected a resolution of 12 bits. WinIQSIM calculates and transfers the IQ data with a resolution of 14 bits (marker signals are accessible). Both the calculated resolution (14 bits) and the selected resolution (12 bits) are stored in the transferred waveform. AMIQ automatically quantizes the waveform to 12 bits when the waveform is loaded into the AMIQ output RAM. You can subsequently increase the output resolution to max. 14 bits.

Note: *If you select a resolution higher than 14 bits, there are generally no markers available in the AMIQ output signal since bits 15 and 16, which are assigned to the markers, in this case contain waveform data.*

Output level of SMIQ
The displayed signal parameters Power Offset, PEP Offset and Crest Factor are for accurate output level setting of Vector Signal Generator SMIQ. Depending on the SMIQ firmware version, Power Offset or the two parameters PEP Offset and Crest Factor have to be used.
If desired, WinQSIM automatically adapts the output level of SMIQ to the current AMIQ signal (see section 5.25.13).

Power Offset: In this field the power offset between an I/Q signal, the vector of which corresponds to the full level equivalent (ie which is on a circle around the center with a radius corresponding to the full level equivalent at the I/Q level), and the current I/Q signal is displayed as a ratio in dB. This value is of particular interest for SMIQ. When the I/Q modulator of SMIQ is driven with a constant sum vector of $\sqrt{I^2 + Q^2} = 0{,}5V$
the current RF level corresponds to the displayed LEVEL value. Consequently, in the case of full-level range the peak envelope power of the modulated RF signal equals the displayed level. The average power is lower. The difference can be corrected by entering an offset in the LEVEL menu (see also section 2.8, Vector Modulation, in the SMIQ manual).
The offset to be set in SMIQ is displayed in the Modulated Power Offset field of WinIQSIM.

PEP Offset: In this field the ratio of the I/Q signal power, the sum vector of which always corresponds to the full level equivalent (ie which is on a circle around the center with a radius corresponding to the full level equivalent also at the I/Q level), to the peak envelope power of the current I/Q signal is displayed in dB. When the Use Peak Value option is selected or a full level equivalent below the peak value is set, the PEP offset is always 0 dB. Only when the full level equivalent exceeds the peak value is the PEP offset greater than 0 dB.

From SMIQ firmware version 4.0, the displayed value will be used for setting the Power Offset (LEVEL menu).

Crest Factor: This field indicates the crest factor, ie the ratio of the maximum instantaneous power of an IQ signal to its average power.
From SMIQ firmware version 4.0, the displayed value will be used for setting the Crest Factor (VECTOR MOD menu).

5.25.4 Prepare for AMIQ Lowpass Filter Panel

A digital-analog converter is used for generating the AMIQ output signal from the transmitted I/Q values. This D/A conversion has two effects. For one, the output signal is distorted in the frequency range sin(f) / f. This effect is taken into account by WinIQSIM and compensated for by means of suitable precorrection.

The second effect is that the D/A converter output signal contains periodically recurring aliasing spectrums of the useful baseband spectrum. The useful spectrum recurs with a frequency spacing that corresponds to an integer multiple of the clock rate. This effect is illustrated in the diagram below.

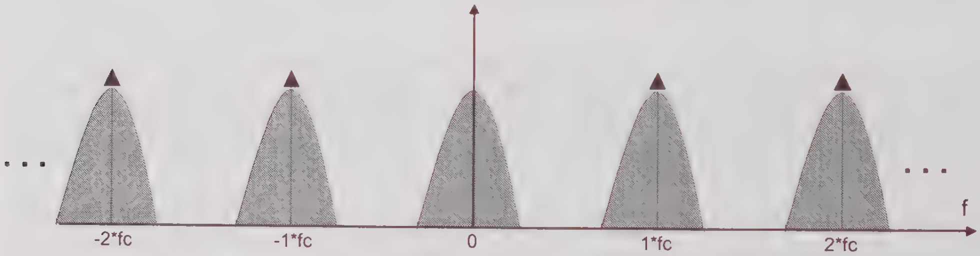


Fig.:5-117 Aliasing spectra at the D/A converter output

The aliasing spectra may cause unwanted impairments when the AMIQ output signal is employed. This effect can be eliminated by means of a suitable lowpass filter for the output signals of the I and Q channels. In the ideal case, the lowpass filter removes the unwanted spectra from the signal without disturbing the useful signal.

The I/Q signal of WinIQSIM can be prepared for such a lowpass filter in the Prepare for AMIQ Lowpass Filter panel. To obtain an optimum filtering effect, the I/Q signal must be sampled at such a high rate that the first aliasing spectrum is completely in the stopband range of the lowpass filter. The useful spectrum should be entirely in the passband range.

The lowpass filters are characterized by two cutoff frequencies. One is the end of the passband range f_1, the other the beginning of the stopband range f_2. Two lowpass filters each are provided in the AMIQ for the I and Q channels. These are the 2.5 MHz filter (f_1 = 2.5 MHz, f_2 = 7.5 MHz) and the 25 MHz filter (f_1 = 25 MHz, f_2 = 75 MHz).

A selection can be made in the **Lowpass Filter** window whether the I/Q signal should be prepared for an internal filter (option **Internal 2.5 MHz** or **Internal 25 MHz**) or an external user filter (option **User/External**). The lowpass filter can be switched off altogether so that the I/Q signal is transmitted without any change to the AMIQ (option **No Filter**).

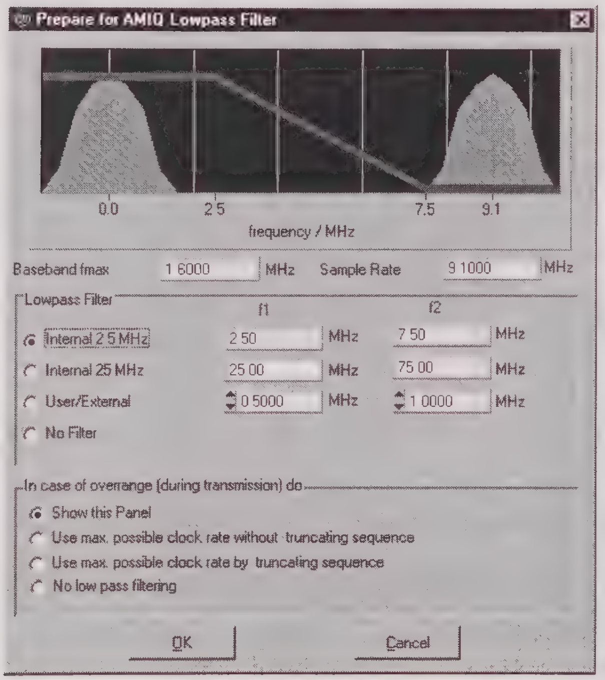
If an external user filter is to be used, the cutoff frequencies f_1 and f_2 of the filter can be specified in the range 0.0001 MHz to 100 MHz in the respective entry fields.

The I/Q signal of WinIQSIM has to be resampled. The obtained sampling rate, which corresponds to the output clock rate of AMIQ, is described by the following relationship:

$$f_{sample\_res} = f_{clock} \geq f_2 + \frac{f_{sample}}{2},$$

ie the resulting sampling rate must be at least as high as the sum of the start frequency of stopband range f_2 and of half the baseband sampling rate. Thus aliasing spectra are thus optimally filtered out.

The current value of half of the baseband sampling rate, which corresponds to the maximum signal frequency (Nyquist), is displayed in MHz in the **Baseband fmax** field. The sampling rate obtained as described above is displayed in MHz in the **Sample Rate** field.
The display at the top of the panel shows the baseband spectrum and its first aliasing spectrum at the current sampling rate. The filter characteristic of the selected lowpass filter is marked in the form of a red bar. The diagram thus shows impairments of the useful signal spectrum and whether the first aliasing spectrum (and all others) are filtered out.



Baseband fmax 1.6000 MHz Sample Rate 9.1000 MHz

Lowpass Filter

	f1		f2	
● Internal 2.5 MHz	2.50	MHz	7.50	MHz
○ Internal 25 MHz	25.00	MHz	75.00	MHz
○ User/External	0.5000	MHz	1.0000	MHz
○ No Filter				

In case of overrange (during transmission) do

- ● Show this Panel
- ○ Use max. possible clock rate without truncating sequence
- ○ Use max. possible clock rate by truncating sequence
- ○ No low pass filtering

Fig.:5-118 Prepare for AMIQ Lowpass Filter panel

When a transmission of the I/Q signal is triggered, the I/Q data are resampled by the program depending on the selected lowpass filter, ie the I/Q signal is prepared for the filter. As a result overranging may occur in the clock frequency and the AMIQ memory depth. The resulting sampling rate could rise above 100 MHz and the number of sampling values, which may be considerably increased by resampling, might be greater than the available AMIQ memory depth (4 million samples).

The response of WinIQSIM to limit violations can be chosen in the **In case of overrange (during transmission) do** window.

Show this Panel: In the case of overranging, the Prepare for AMIQ Lowpass Filter panel is displayed. In this panel further functions can be selected (no filter, selecting another filter, etc).

Use maximum possible clock rate without truncating sequence: The highest possible clock rate without truncating the I/Q signal sequence is set. Setting the desired sampling frequency would cause the maximum memory depth of AMIQ to be exceeded. Before resampling is performed, WinIQSIM determines the highest possible sampling frequency at which the sequence is not truncated. Avoiding loss of signal information is given highest priority.

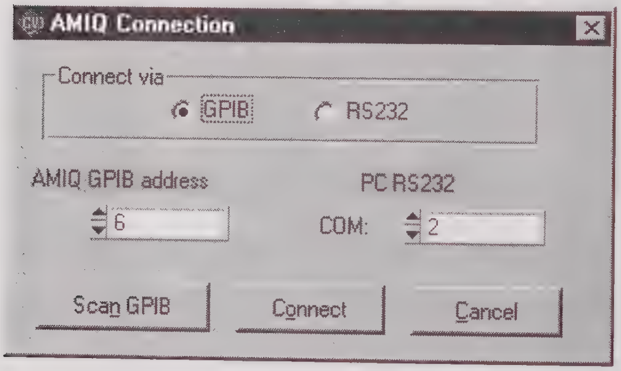
Use maximum possible clock rate by truncating sequence: The highest possible clock rate by truncating the I/Q signal sequence is set. This option is only useful when the information content of the I/Q signal is of less importance (eg modulation with PRBS data) and priority is given to spectral characteristics. Obtaining a maximum clock rate for optimum lowpass filtering has highest priority in this case. The sequence length of the I/Q signal before resampling is reduced when only part of the signal is used. As a result the clock rate can be further increased.

No lowpass filtering: If resampling leads to overranging, the signal is not prepared for lowpass filtering.

5.25.5 AMIQ Remote Control And BERT Panel

All actions concerning AMIQ remote control can be triggered in the AMIQ Remote Control panel. In addition to loading and starting I/Q signals, the marker channels can be influenced, hardware settings and adjustments made in the AMIQ, and waveform files managed on the AMIQ hard disk. If the BER measurement option of AMIQ (AMIQ-B1) is available, the control panel for the BER measurement is also accessible from this panel. The AMIQ Remote Control panel and all associated windows are modal windows, ie the active window must be closed before settings can be made in any other.

To allow remote control of AMIQ, a connection to AMIQ (GPIB/IEEE 488.2 or RS232) has to be set up first. If **Automatically retry previous interface** has been selected in the **Interface and Transmission Options** panel, an attempt is made to access AMIQ under the address/interface used for the last successful connection. If this attempt fails or if the option is not selected in the Interface and Transmission Options panel, the following panel is displayed.



AMIQ GPIB address: 6

PC RS232 COM: 2

Fig.:5-119 AMIQ Connection panel

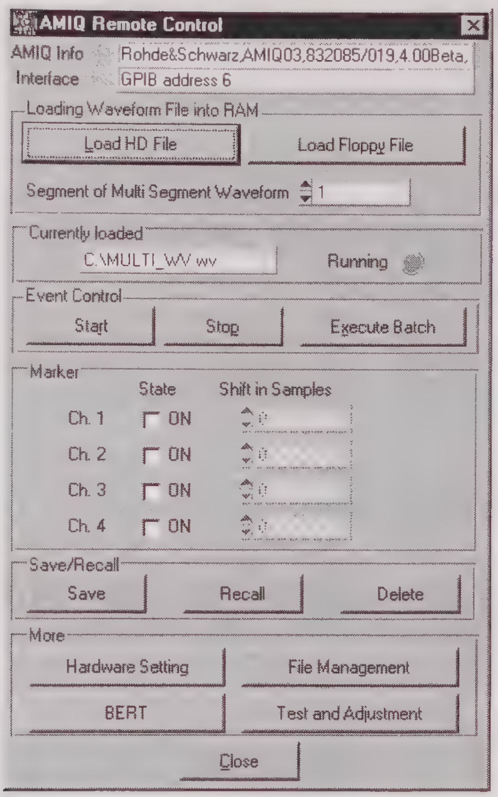
Here the interface (GPIB/IEEE 488.2 or RS-232) and the address for the desired AMIQ connection can be selected. If your AMIQ is connected to the GPIB/IEEE 488.2 bus and you do not know its address, an automatic search for AMIQ can be triggered with the Scan GPIB button.

Note: *The PC on which WinIQSIM is installed, must be the controller on the GPIB/IEEE bus. In case of any problems please refer to chapter 5.25.12 Several Controllers on the Bus/AMIQ Controlled from Signal Generator SMIQ.*

After the connection to AMIQ has been established, the **AMIQ Remote Control** panel is displayed.

The device identification of AMIQ (answer to query "*idn?") is displayed in the **Info** field.
It has the following syntax: "**Rohde&Schwarz, AMIQ, ssssss/sss, x.yy**" with ssssss/sss being the serial number and x.yy the software version.

The interface via which the communication with AMIQ takes place (GPIB or RS 232) and the address of the AMIQ with GPIB (default 6) or the baud rate used with RS 232 is displayed in the **Interface** field.



AMIQ Remote Control

AMIQ Info: Rohde&Schwarz,AMIQ03,832085/019,4.00Beta,

Interface: GPIB address 6

Segment of Multi Segment Waveform: 1

Currently loaded: C:\MULTI_WV.wv

Running

Marker	State	Shift in Samples
Ch. 1	☐ ON	0
Ch. 2	☐ ON	0
Ch. 3	☐ ON	0
Ch. 4	☐ ON	0

Fig.:5-120 AMIQ Remote Control panel

Loading waveform file into RAM

In this window an I/Q waveform file can be selected from the AMIQ hard disk (**Load HD File**) or the AMIQ floppy disk drive (**Load Floppy File**). The file is then loaded into the AMIQ output memory. Pressing the **Load HD File** or **Load Floppy File** button opens a file selection window.

The **Segment of Multi Segment Waveform** field allows you to select the partial segment of the multisegment waveform currently loaded in the output memory, which is to be output. This field can be accessed only if a multisegment waveform has been loaded (Load HD File). The values range from 1 to the number of segments of the current waveform. For details, refer to section 5.25.8.

Window for selecting an I/Q signal file: In this window the I/Q signal file to be loaded into the AMIQ output RAM can be selected. The directory from which a waveform file is to be selected can be chosen from the list at the right. All waveform files (fixed extension *.wv) in the selected directory are then listed at the left. Here a file can be selected with the left mouse key. Confirm your choice with the **Return** key or the **Select** button. The selected file is then loaded into the output RAM. The selection can be aborted with the **Cancel** button.

In the list of files, the file size in bytes is indicated in brackets after the file names.
The memory used on the hard disk of the AMIQ and the still available memory are indicated in kilobytes in the field **AMIQ Hard Disk Info.**

In this file selection window, the multisegment waveforms (MWV) are characterized by an appropriate appendix to the file name.

With the **Info** button a variety of information items on the selected waveform file can be displayed in the **File Info** field. The following parameters can be indicated in the case of standard waveforms:

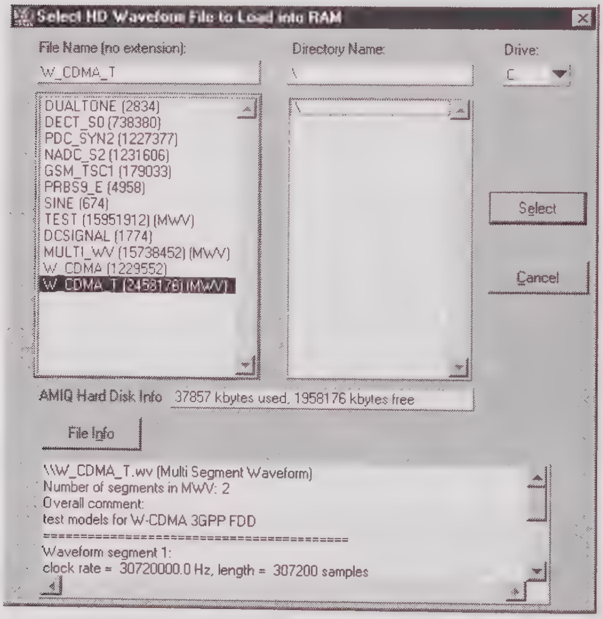
- complete file path, in the case of IF signals also the notation **IF signal** and the file date and time

- the system used to generate the signal in WinIQSIM (Single Carrier, Multi Carrier, 3 GPP W-CDMA or IS 95)
- user comment on I/Q waveform entered in the Transmission panel prior to transmission
- clock for waveform output.
- power offset: the difference as specified by modulation between the effective power at full-scale level and the carrier power with modulation (see chapter Signal Statistics and Quantization).
- PEP offset: the difference between full-scale level and peak envelope power (Peak Envelope Power) (see chapter Signal Statistics and Quantization)
- the names of the marker channels selected in the Marker Setting panel.

With multisegment waveforms, the following information is displayed:

- complete file path,
- number of segments,
- total comment on MWV,
- clock rate, length and WinIQSIM™ system used to generate each segment, and a comment on the segment

This function simplifies management and selection of waveform files by providing further information in addition to the 8-character file name.



File Name (no extension): W_CDMA_T

Directory Name: \

Drive: C

DUALTONE (2834)
DECT_S0 (738380)
PDC_SYN2 (1227377)
NADC_S2 (1231606)
GSM_TSC1 (179033)
PRBS9_E (4958)
SINE (674)
TEST (15951912) (MWV)
DCSIGNAL (1774)
MULTI_WV (15738452) (MWV)
W_CDMA (1229552)
W_CDMA_T (2458176) (MWV)

AMIQ Hard Disk Info: 37857 kbytes used, 1958176 kbytes free

```
\\W_CDMA_T.wv (Multi Segment Waveform)
Number of segments in MWV: 2
Overall comment:
test models for W-CDMA 3GPP FDD
========================================
Waveform segment 1:
clock rate =  30720000.0 Hz, length =  307200 samples
```

Fig.:5-121 Panel for selecting an I/Q waveform file

In the **Currently Loaded** field, the waveform file presently in the AMIQ output memory is indicated.

Event Control
In this window the AMIQ signal output can be started and stopped and the AMIQ batch floppy previously generated in the Transmission panel can be executed.

Start / Arm: The label of the Start / Arm button changes depending on the set trigger mode. The button is labelled **Arm** for all modes expecting an external trigger event (Gated, Ext auto, Ext single). AMIQ is armed in order to start on an external trigger event. With all other trigger modes the button is labelled **Start.** AMIQ is armed and a trigger signal is sent which starts the signal output.

Stop: The signal output is terminated with this button. A wait pattern is output.

Execute Batch: The batch file winiqsim.iec is executed by the floppy in the AMIQ floppy disk drive. This batch file can be created in the Transmission panel (see section 5.25.1). The signal data and the directory structure of the floppy are stored on the hard disk of AMIQ.

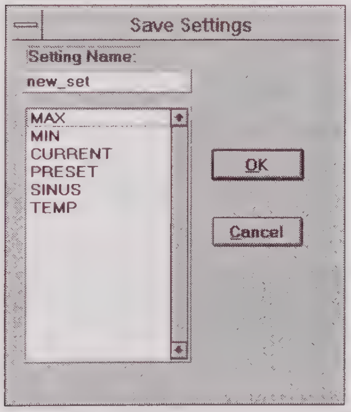
Marker

Four AMIQ marker channels can be switched on and off in the Marker window. The markers of the channels can also be shifted.
The output for each marker channel can be activated by checking **State ON**. The marker of the channel can be shifted by the set number of samples in the **Shift in Samples** entry fields. Negative values advance the marker in the time domain, positive values delay it. Since the marker shift is performed in a ring buffer no marker positions are lost. Markers shifted beyond the end of a waveform appear again at the beginning. Shifting the marker in the individual channels is not a characteristic of the current waveform file but a device characteristic. The marker shift is also valid for the new waveform when another file is called. Use the Save/Recall memories for storing the marker shifts together with the waveform (see below).

Save/Recall

Save/Recall memories are provided in AMIQ. With the aid of these memories the complete AMIQ setup can be stored and called again later on. With the **Save**, **Recall** and **Delete** buttons the device configurations can be stored, called or cleared.

Save: With this button the current AMIQ setup can be stored. A window is opened where a name can be assigned to the settings to be stored or an already stored setting can be overwritten. Confirm your selection with the **OK** button in this panel. The AMIQ setup will be stored under the entered name. The action can be aborted with the **Cancel** button.



Setting Name: new_set

Fig.:5-122 Save/Recall selection window

Recall: With this button a previously stored AMIQ setup can be called. A window is opened where a stored setup can be selected (see Save).

Delete: With this button a previously stored AMIQ setup can be cleared. A window is opened where a stored setup can be selected (see Save).

More

Pressing the **Hardware Settings**, **File Management** and **Test and Adjustment** buttons in the **More** window opens setting windows which are described in detail further down.

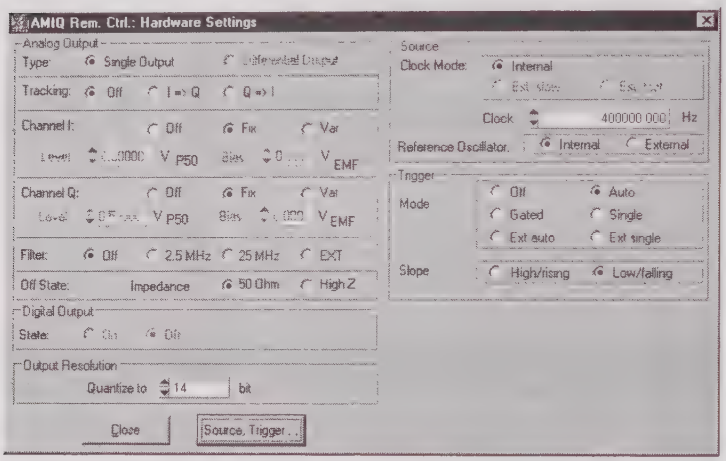
If the BER measurement option of AMIQ (AMIQ-B1) is available, the **BERT** button is active (not dimmed). With this button the control elements for the BER measurements can be added to the panel. For a detailed description of this function refer to chapter 6 BER measurement with Option AMIQ-B1.

With the **Close** button of the AMIQ Remote Control panel the panel is quit and the connection to AMIQ cut off.

5.25.6 Hardware Settings Panel

In the Hardware Settings panel of AMIQ, device settings like output level, lowpass filter and trigger mode can be made.

To provide a better overview, only the left half of the panel is displayed first (without the Source and Trigger windows). To display these windows, click on the **Source, Trigger** button.



Type: ● Single Output ○ Differential Output

Tracking: ● Off ○ I => Q ○ Q => I

Channel I: ○ Off ● Fix ○ Var

Channel Q: ○ Off ● Fix ○ Var

Filter: ● Off ○ 2.5 MHz ○ 25 MHz ○ EXT

Off State: Impedance ● 50 Ohm ○ High Z

State: ○ On ● Off

Quantize to 14 bit

Clock Mode: ● Internal

Clock 400000 000 Hz

Reference Oscillator: ● Internal ○ External

Mode: ○ Off ● Auto ○ Gated ○ Single ○ Ext auto ○ Ext single

Slope: ○ High/rising ● Low/falling

Fig.:5-123 Hardware Settings panel

Output
In the first window of this panel, the output levels of the I and Q channels can be configured and the desired lowpass filter selected.

Type: The type of output can be determined here. If the option Differential Outputs (AMIQ-B2) is fitted in the AMIQ, you can choose between Single Output and Differential Output. If this option is not provided, the respective select item is dimmed.

Tracking :The Tracking parameter permits to determine whether the level modes and level parameters for the channels I and Q can be set independently of each other or together.

- Tracking **Off**: The level settings for channel I and Q are independent of each other.
- Tracking **I => Q**: The level settings for the I channel automatically apply to the Q channel as well. The fields for setting the Q channel are shaded. They can no longer be operated. The currently valid values of the Q parameters however are entered.
- Tracking **Q => I**: The level settings for the Q channel automatically apply to the I channel as well. The fields for setting the I channel are shaded. They can no longer be operated. The currently valid values of the I parameters however are entered.

Level: Three different level modes can be selected separately for the I and Q channels (Tracking Off).

- Level **Off**:
  Single Output: the respective output is switched off.
  Differential Output: only the DC level set in the Bias field is still applied to the respective outputs.
- Level **Fix**:
  Single Output: fixed setting to 0.5 V Peak into 50 Ω (V_{P50}).
  Differential Output: fixed setting of an open-circuit voltage (EMF) of 2 V (V_{EMF}).
- Level **Var**:
  Single Output: variable level setting; the level can be varied between 0 and 1 V_{P50} in the level I and Q fields (corresponds to 0 to 2 Vpeak to peak). The level I and Q fields are only accessible when **Var**

is selected for the respective channel.
Differential Output: variable level setting; the level can be varied between 0 and 4 V_{EMF} in the level I and Q fields (open-circuit voltage). The level I and Q fields are only accessible when **Var** is selected for the respective channel.

Bias: If the AMIQ is equipped with differential outputs and the Differential Output Type is switched on, a bias level (operating point of DC voltage) can be set in the range from –2.5 V_{EMF} to 2.5 V_{EMF} (open-circuit voltage) for channels I and Q. Otherwise, the bias fields are not accessible. The tracking option also affects the bias levels.

Filter: The lowpass filter to be cut into the signal paths of the I and Q channels is selected under Filter in the Output window. WinIQSIM allows the I/Q signal to be especially prepared for one of these lowpass filters. For further information see section 5.25.4. Four different filter modes are available. They can only be set together for the I and Q channels.

- Filter **Off**: output of unfiltered I/Q signals
- Filter **2.5 MHz**: the internal 2.5 MHz lowpass filter is cut in
- Filter **25 MHz**: the internal 25 MHz lowpass filter is cut in
- Filter **EXT**: External lowpass filters are cut into the I and Q channels. A detailed description of the filters is given in the "Signal Inputs and Outputs" section in the AMIQ operating manual.

Note: *With external filtering selected, a filter should be connected to the two I and Q filter inputs at the rear of AMIQ, as otherwise the two signal outputs could get switched off.*

Off State
The input impedance of the AMIQ can be determined with the outputs switched off.
Single Output: It is possible to select between an input impedance of 50 Ohm and a high-impedance input (High Z).
Differential Output: It is possible to select between an input impedance of 50 Ohm and a high-impedance input (High Z). If High Z is selected, the bias level is forced to 0 due to the high impedance with the outputs switched off.

Output Resolution:
Here you can select the output resolution of AMIQ. The range of values depends on the resolution calculated for the current waveform and is from 8 bits to max. 14 bits for analog IQ outputs and 16 bits for digital IQ outputs. The resolution with which the waveform is calculated is always the upper limit. It can however be reduced by the user.

Note: For an output resolution higher than 14 bits the marker channels of AMIQ are disabled. The control elements for the marker channels in the AMIQ Remote Control panel are dimmed in this case.

Source
In the Source window, the output clock rate of AMIQ can be set and the reference oscillator mode selected.
In the **Clock Mode** window, internal or external clock generation can be selected. The Ext. Slow and Ext. Fast clock modes will be available from AMIQ model 03. For model 02 only the internal mode exists.
For more detailed information please refer to the AMIQ operating manual.

In the **Clock** field the currently selected output clock rate of AMIQ is indicated in Hz. The output clock rate can be varied in this field. After the first attempt to change the set clock rate a warning is output that a change of the clock rate may cause errors in the output signal. The permissible setting range for the clock rate is 100 Hz to 100 MHz.

A selection can be made in the **Reference Oscillator** window whether the internal or an external reference clock should be used for setting the synchronization.

- Reference Oscillator **internal**: the internally generated 10 MHz clock is used
- Reference Oscillator **external**: The frequency can be synchronized to an external 10 MHz clock via the REF input of AMIQ.

Note: *The highly accurate 10 MHz clock of the internal reference oscillator is always output at the REF output of AMIQ.*

Trigger
In this window the sequence control for the signal output and the polarity of the external trigger signals can be configured.

Mode: Configuration of sequence control for signal output. Each time sequence control is changed, the signal output is reset and restarted. Retrigger of an ongoing signal output is disabled. The following six trigger modes can be selected:

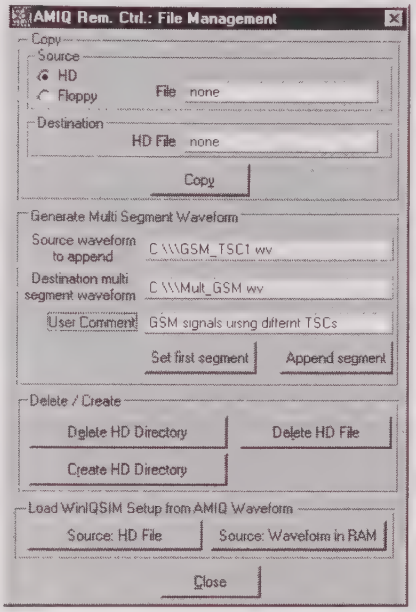
- **Off**: Terminates the signal output; an idle signal is output.
- **auto**: Continuous signal output, trigger events are ignored. then the signal output is triggered with the **Start** button in the AMIQ Remote Control panel.
- **single**: A single signal output is set up. First the idle signal is output, then the signal output is triggered with the **Start** button in the AMIQ Remote Control panel. When the signal output is completed, the idle signal is output again. External trigger events are ignored.
- **gated**: The output is controlled by the signal level at the trigger input. If the level (high/low) set under **Trigger Slope** (see below) is present, the output is restarted and the signal is continuously output. If the level (high/low) set under **Trigger Slope** (see below) is not present, the signal output is stopped and the idle signal output. AMIQ is activated with the **Arm** button in the AMIQ Remote Control panel. Only then will it respond to external trigger events.
- **ext-auto**: Continuous signal output. First the idle signal is output, then signal output is started by an external trigger event. Further trigger events are ignored. A trigger event is a signal edge the polarity (high/low) of which has been configured under **Trigger Slope** (see below). AMIQ is activated with the **Arm** button in the AMIQ Remote Control panel. Only then will it respond to external trigger events.
- **ext-single**: A single signal output is set up. First the idle signal is output, then signal output is started by an external trigger event. With the signal output completed, the idle signal is sent until the next trigger event. AMIQ is activated with the **Arm** button in the AMIQ Remote Control panel. Only then will it respond to external trigger events.

Slope: The polarity of an external trigger signal (TRIG connector) generating a trigger event for sequence control can be set here. This setting affects the modes **Gated**, **Ext auto** and **Ext single**. The polarity **High/rising** or **Low/falling** can be selected.

With the **Close** button the Hardware Settings panel is quit and the AMIQ Remote Control panel entered again.

5.25.7 File Management Panel

The File Management panel provides functions for the management of waveform files on the AMIQ hard disk. These functions are described in the following.



● HD
○ Floppy
File: none
HD File: none
Source waveform to append: C \\\GSM_TSC1 wv
Destination multi segment waveform: C \\\Mult_GSM wv
User Comment: GSM signals ursng diffemt TSCs

Fig.: 5-124 File Management panel

Copy
In the Copy window, a waveform file on the AMIQ hard disk or disk drive can be copied into a directory on the AMIQ hard disk. By selecting **HD** or **Floppy** in the Source window, the user determines whether a file of the hard disk or the disk drive should be copied. A click with the left mouse key on the File field opens a window where the file to be copied can be selected. Under **Destination** the destination for copying can be defined in the same way. After file source and destination have been specified, copying can be started with the **Copy** button.

Generate Multi Segment Waveform
This part of the panel is described in the next section (5.25.8).

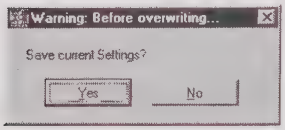
Delete/Create
In this window directories can be created and cleared and waveform files cleared.
Delete HD Directory: Pressing this button opens a selection window. The waveform file directory to be cleared can be selected on the hard disk. The selected directory is cleared after confirmation. Directories containing files can also be cleared.

Create Directory: With this button a new directory can be created on the hard disk (only one directory level can be created below the root node). A window is opened where the new directory name can be entered. A name comprising a maximum of eight characters (DOS name) can be entered.

Delete File: Pressing this button opens a selection window where the file to be cleared on the hard disk can be selected. The selected directory is cleared after a confirmation query.
Load WinIQSIM Setup from AMIQ Waveform:
In this window, a WinIQSIM setup (*.iqs file) used for generating a waveform in AMIQ can be read out from the associated waveform file in AMIQ and loaded into WinIQSIM. This is possible only if the relevant WinIQSIM setup was transmitted to AMIQ together with the waveform data (see section 5.25.1).

In this way the WinIQSIM parameters are again available separately from the associated IQ waveform. It can be seen how the IQ signal was generated, and the original IQ signal can be varied by editing parameters.
With the **Source: HD File** and **Source: Waveform in RAM** buttons you can select whether the source waveform for loading the setup is to be fetched from the AMIQ hard disk or from the output RAM.

Prior to reading the WinIQSIM setup from the AMIQ waveform, which will overwrite the current WinIQSIM settings, you can save the current setup:



Save current Settings?

Fig.: 5-125

If "Yes" is clicked on, the usual dialog for storing the WinIQSIM setup will appear. With "No", WinIQSIM will immediately start reading the setup from AMIQ. This setup is stored under the name AMIQ_WV.iqs and automatically loaded into WinIQSIM.

With the **Close** button the File Management panel is quit and the AMIQ Remote Control panel entered again.

5.25.8 Generate Multisegment Waveform

This section of the File Management Panel is used to generate multisegment waveforms. In the following, multisegment waveforms and their possible applications are described. An explanation on how to operate this section is then given.

5.25.8.1 Application and Structure of Multisegment Waveforms

In particular when the AMIQ is used in automatic test equipment (ATE), the components to be tested must be operated by a wide variety of test signals. To minimize the test time, the change between the individual test signals must be as rapid as possible. Loading the new signals from the AMIQ hard disk should be avoided, if possible. The multisegment waveform (MWV), which is implemented in the AMIQ as of firmware version 4.0.0, meets this requirement.

Superficially, an MWV is similar to a usual waveform in the AMIQ. Its maximum length depends on the AMIQ model (4 Msamples with AMIQ03, 16 Msamples with AMIQ04). What makes the MWV special is the fact that it can consist of up to 30 partial traces, the segments.

Each segment can be considered an independent waveform (with its own marker assignment and clock rate). The complete waveform is loaded into the output RAM of the AMIQ, where a segment (with start address and length) can be selected and output. It is then possible to change between the segments (partial signals) without reloading the output RAM. Simply specify a new segment index. A rapid change between the partial signals, and, consequently, an acceleration of the test procedure is thus possible.

The structure of the AMIQ output RAM requires the multisegment waveforms to comply with the following conditions:

- The maximum number of segments is 30.
- The minimum length of each segment must be 128 ksamples (= 131.072 samples).
- The segment length in samples must be a multiple of 4.
- For a fast segment change, it is recommended that all segments be generated with the same clock rate. The clock rate can easily be changed in each new segment.

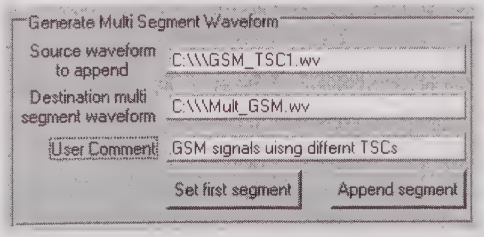
The AMIQ ensures compliance with these conditions. The user only needs to specify which standard waveforms in the AMIQ he or she would like to combine to form a multisegment waveform. The AMIQ automatically meets the conditions placed on length by repeating the basic waveform of a segment.

Once a multiwaveform has been generated, it can be loaded and output like any other waveform.

The next section describes the operating steps for generating an MWV.

5.25.8.2 Generation of a Multisegment Waveform

Before generating an MWV, transfer to the AMIQ hard disk all standard waveforms you want to combine to form an MWV. You can then perform all further steps in the File Management Panel in the **Generate Multi Segment Waveform** section.



Source waveform to append: C:\\\GSM_TSC1.wv

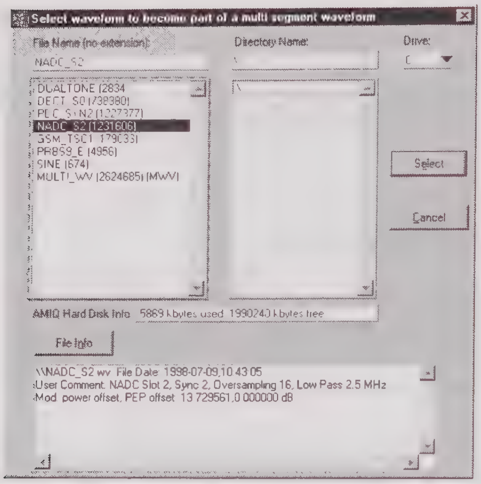
Destination multi segment waveform: C:\\\Mult_GSM.wv

User Comment: GSM signals uisng differnt TSCs

Fig.: 5-126 Generation of an MWV

Source waveform to append

In this field, select the standard waveform you want to append to the current multisegment waveform as the next (or first) segment. If you click in the field, the usual file selection dialog is opened, which you already know from other WinIQSIM operating steps.



File Name (no extension): NADC_S2

Directory Name: \

Drive: C

DUALTONE (2834
DECT_S0 (738380)
PLC_SIN2 (1227377)
NADC_S2 (1231606)
GSM_TSC1 (79033)
PRBS9_E (4956)
SINE (674)
MULTI_WV (2624685) (MWV)

AMIQ Hard Disk Info 5869 kbytes used 1990240 kbytes free

```
\\NADC_S2.wv  File Date: 1998-07-09,10:43:05
User Comment: NADC Slot 2, Sync 2, Oversampling 16, Low Pass 2.5 MHz
Mod. power offset, PEP offset: 13.729561,0.000000 dB
```

Fig.: 5-127 Dialog for waveform selection in the AMIQ

Destination multisegment waveform
In this field, select the multisegment waveform which is to be generated or extended. If you click in the field, the usual file selection dialog is opened, which you already know from other WinIQSIM operating steps.

User comment
You can enter a comment on the total MWV, which can later be read from the MWV (e.g. in the waveform file selection window).

Set first segment
If you select this button, a new MWV is created on the AMIQ hard disk. This MWV consists only of the segments selected in the **Source waveform to append** field.

Append segment
If you select this button, the segment selected from the **Source waveform to append** field is appended to the MWV selected.

Possible error messages when generating an MWV

- *Selected waveform is a multi segment waveform but has to be a standard waveform*: It is not possible to append segments which are multisegment waveforms themselves. Please select a standard waveform to be appended.
- *Selected waveform is a standard waveform but has to be a multi segment waveform*: Please select an existing (or new) MWV for Append... or Set first... .
- *Maximum number of segments (30) in destination waveform file exceeded*: The maximum number of 30 segments of an MWV in the AMIQ cannot be exceeded.
- *Resulting waveform length in destination MWV exceeds maximum length*: The maximum total length of an MWV (4 Msamples or 16 Msamples, depending on the AMIQ model) is exceeded. The new segment can no longer be appended.

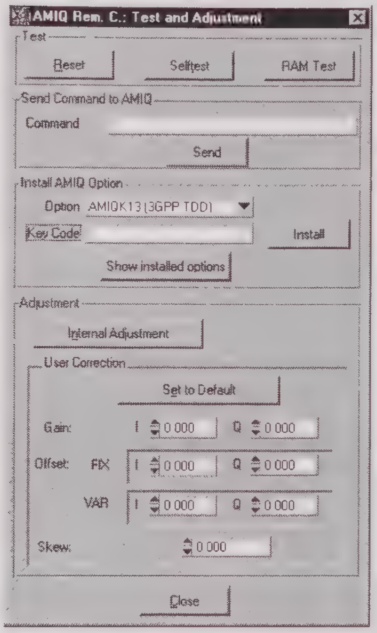
5.25.8.3 Deleting Segments of a Multisegment Waveform

If you no longer require the segments of a multisegment waveform, or if you have already reached the maximum segment number in an MWV and want to replace a segment, you can use the Delete Segment function. This will save you having to generate a completely new MWV. Simply delete the segment which is no longer required from the trace, and append a new segment to the trace. To do so, use the **Delete Segment of MWV** field.

Select the MWV from the **Multi Segment Waveform** field, from which a segment is to be deleted. Next, indicate the index of the segment to be deleted under **Segment to delete**, and start deletion by pressing the **Delete segment** button. If the MWV consists of one segment only and you delete it, the complete MWV file is removed from the AMIQ hard disk.

5.25.9 Test and Adjustment Panel

In this panel alignment and selftest functions of AMIQ can be called up.



Option AMIQK13 (3GPP TDD)

Gain: I 0.000 Q 0.000

Offset: FIX I 0.000 Q 0.000

VAR I 0.000 Q 0.000

Skew: 0.000

Fig.:5-128 Test and Adjustment panel

Test

The **Reset, Selftest** and **RAM Test** functions are available in the Test window.

With the **Reset** button, AMIQ is reset to a defined default state.

An automatic test can be triggered with the **Selftest** button. The result of this test, ie the success or the failure, is indicated in the form of a message.

A test of the AMIQ waveform memory (SDRAM) can be started with the **RAM Test** button. The result of this test is signalled by a message.

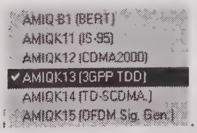
Send Command to AMIQ

In the **Command** field of this panel section a command string can be entered which is to be sent to AMIQ. Pressing the **Send** button sends the string entered in the Command field to AMIQ. Queries are not possible. They will be rejected automatically.

Example: This function may be used to select a control file for option AMIQ-B1 (BER measurement), after the latter has been activated, by sending the command string*: BERT:SEL 'PRBS'* to AMIQ.

Install AMIQ Option

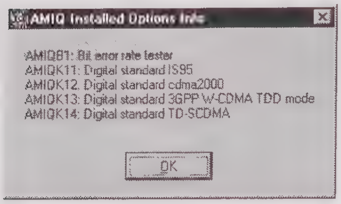
The functions in this section are used to enable software options in the AMIQ. The option to be installed is selected in the **Option** field. The following options are provided:



AMIQ-B1 (BERT)
AMIQK11 (IS-95)
AMIQK12 (CDMA2000)
✓ AMIQK13 (3GPP TDD)
AMIQK14 (TD-SCDMA)
AMIQK15 (OFDM Sig. Gen.)

Insert the key code supplied with the option in the **Key Code** field and terminate the action with the **Install** button.

The options that are currently installed in your AMIQ are displayed if you press the **Show installed options** button:



AMIQB1: Bit error rate tester
AMIQK11: Digital standard IS95
AMIQK12. Digital standard cdma2000
AMIQK13: Digital standard 3GPP W-CDMA TDD mode
AMIQK14: Digital standard TD-SCDMA

Adjustment
In this window the internal alignment of AMIQ can be called up and user corrections entered.
Internal Adjustment: The automatic alignment of AMIQ is started:

- Level adjustment (I/Q) to 1,0 V when fully driven
- Offset adjustment (I/Q) to minimum
- Fine tuning of reference oscillator to 10 MHz
- Minimizing the skew between I and Q channel

User Correction
In the User Correction window, level and offset of the I and Q channels can be accurately adjusted and the skew between the channels in the system as a whole can be reduced to a minimum.
The **Internal Adjustment** is not affected.

Set to Default: User corrections are reset to original values.
This applies to the following parameters:

- LEVEL I GAIN (*)
- OFFSET I FIX (*)
- OFFSET I VAR (**)
- LEVEL Q GAIN (*)
- OFFSET Q FIX (*)
- OFFSET Q VAR (**)
- SKEW (I-Q)

* These parameters are only active when the respective channel is in the Fix mode.
In the variable level mode, settings for these parameters are not effective. A possible correction of the gain factor should in this case be made when the level is entered.
** These parameters are only effective with variable levels; with fixed levels they are disabled.

Gain I, Q: Fine adjustment of gain factor for the I or Q channel in the fixed level mode (Fix). The gain can be adjusted between -1.0 and 1.0, the value 0.0 corresponds to a gain of 1.0. Simple conversion of setting values into actual gain factors is not possible except for 0.0. The resulting variation of the AMIQ gain factor is +/- 10%.

Offset I, Q Fix: Fine adjustment of level offset for the I or Q channel in the fixed level mode (Fix). The offset can be adjusted between -1.0 and 1.0; 0.0 corresponds to the minimum offset. Range limits are –30 mV and 30 mV (into 50 Ohm), the step width is 30 μV.

Offset I, Q Var: Fine adjustment of level offset for the I or Q channel in the variable level mode (Var). The offset adjustment depends on the setting of the mechanical attenuator of AMIQ. Refer to section "SOURce - Hardware Settings" in the AMIQ manual.

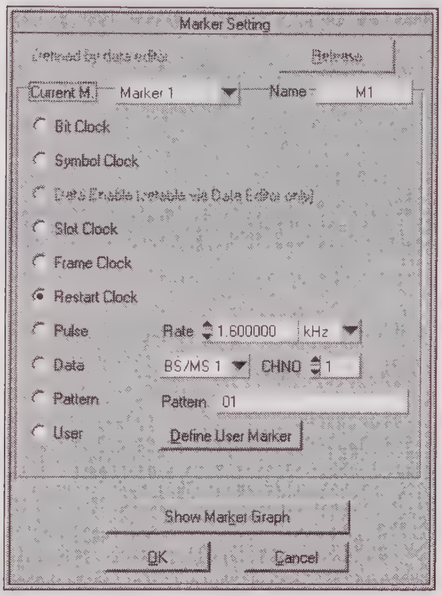
Skew: Determines the delay between the I and Q channel. Positive values delay I against Q. The skew can be varied by entering the relative factors ±1.0 in a range of approx. ±1 ns with a resolution of 10 ps.

With the **Close** button the Test and Adjustment panel is quit and the AMIQ Remote Control panel entered again.

5.25.10 Marker Setting Panel

Besides the I/Q outputs, AMIQ is provided with four digital, user-programmable marker channels that can be set with sample accuracy. The outputs are controlled by the waveform memories (16-bit word width) for I and Q. In this case, the two least-significant bits (LSBs) of the waveform memory are set for the I and Q channels.

The marker outputs are normally used for the control of power ramping of I/Q modulators to increase the dynamic switch-off range. The marker outputs can be used separately, eg with AMIQ employed as a universal trigger generator.
While in the data editor the marker channels can be configured at the data bit level, marker setting in this panel is at the sample level.



Marker Setting

Defined by data editor — Release

Current M.: Marker 1 — Name: M1

○ Bit Clock
○ Symbol Clock
○ Data Enable (settable via Data Editor only)
○ Slot Clock
○ Frame Clock
● Restart Clock
○ Pulse — Rate 1.600000 kHz
○ Data — BS/MS 1 — CHNO 1
○ Pattern — Pattern 01
○ User — Define User Marker

Fig.:5-129 Marker Setting panel

Current Marker: In this selection field the channel to be processed (1 to 4) can be chosen. A name of up to 5 characters can be assigned to each channel in the **Name** field for distinguishing the marker channels.

In the window below various marker signals can be selected which are described in detail in the following.

Bit Clock
If a marker channel is to furnish a bit clock, the **Bit Clock** option can be activated. For generating a bit clock at regular intervals, oversampling must be an integer multiple (minimum factor 2) of the modulation order. The bit clock is generated by a low-to-high transition preferably in the middle of a bit.

Example: With 8-fold oversampling and a modulation level of 2 (eg QPSK), a data bit takes up 4 samples of the AMIQ trace. In this case, a bit clock consists of 2 low (0) samples and 2 high (1) samples.

Symbol Clock
If a marker channel is to furnish a symbol clock, the **Bit Clock** option can be activated. For generating a bit clock at regular intervals, oversampling must be 2 at the minimum. The symbol clock is generated by a low-to-high transition preferably in the middle of a symbol.

Data Enable (settable via data editor only)
A data enable signal for the BER test can be defined in the data editor. This signal is output to a marker channel and can only be defined by way of the data editor. For more detailed information refer to chapter 6, BER Measurement with Option AMIQ-B1

Slot Clock
With this option selected, a slot clock signal is assigned to the selected marker channel, depending on the currently used system. This option is not available in all systems. In the 3GPP W-CDMA system, a slot clock of for instance 10 ms (corresponds to a frame) is set depending on the chip rate 1/15 or 1/16.

Frame Clock
With this option selected, a frame clock signal is assigned to the selected marker channel, depending on the currently used system. This option is not available in all systems. In the 3GPP W-CDMA system, a frame clock of for instance 10 ms (corresponds to a frame) is set.

Restart Clock
With this option selected, a restart signal can be generated on a marker channel. The first marker positions of the selected channel are set to high (1), all subsequent positions to low (0). This signal marks the trace start in the AMIQ after the wraparound and can be used for synchronization.

The Restart and Bit Clock functions are also needed for BER measurements with AMIQ (see also chapter 6, BER Measurement with Option AMIQ-B1).

Pulse
With this option active, a user-defined clock signal can be assigned to a marker channel. To do so, enter the desired clock rate in the associated **Rate** entry field.

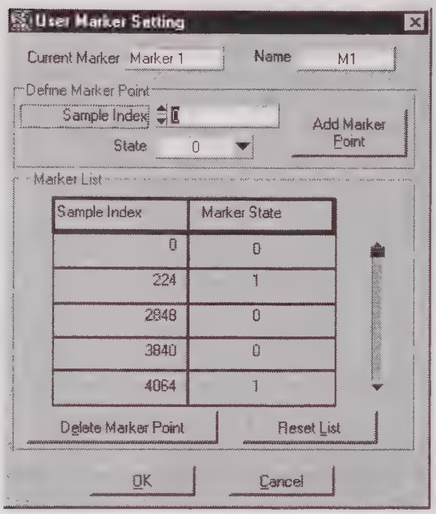
Data
With this option selected, the information data can be assigned to a marker channel. The information data are then output synchronously with the corresponding I/Q samples. This option is not available in all systems. Since only one data source is available in the single carrier system, the data flow for the marker is unambiguously defined. In the different (W-)CDMA systems, the base station and the mobile station can be specified in addition with the desired channel number. This unmistakably defines the data flow to be used for the marker. All data bits of the selected channels including pilot bits and similar data fields are output.
The data marker is only available for marker channel 1.

Pattern
With this option a bit pattern to be assigned to the marker channel can be defined. The bit pattern is then cyclically repeated and output.

User
With this option a user-defined marker list can be output for each marker channel. For more details refer to the following section.

5.25.10.1 User Marker Setting

Pressing the **Define User Marker** button opens a panel where a marker list can be defined by the user.



User Marker Setting

Current Marker: Marker 1
Name: M1

Define Marker Point
Sample Index: 0
State: 0

Marker List

Sample Index	Marker State
0	0
224	1
2848	0
3840	0
4064	1

Fig.:5-130 User Marker Setting panel

Define Marker Point
In this window the time template of the output values of the currently selected marker channel can be determined. To do so enter a sample position in the **Sample Index** field and the corresponding status of the marker channel (0 or 1) at this position in the **State** field. Using the **Add Marker Point** button the new position is transferred to the marker list in the lower part of the panel. Only the positions at which the marker signal should change need to be specified. The marker signal remains at the last set value until the sample position entered in the marker list with another status is attained.
This principle is illustrated by the table and diagram below.

Sample position	Status
0	0
5	1
12	1
18	0
23	1

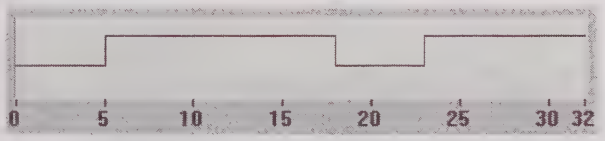


Fig.:5-131 Example of a marker characteristic

Using the scrollbar at the left of the list, the user may scroll through the list to view all entries and select a list item with the mouse. The selected item is highlighted by an orange frame. The Sample Index and State of this entry are transferred to the **Define Marker Point** window where they can be easily modified.

With the **Delete Marker Point** button, the entry selected in the list (orange frame) is cleared. The **Reset List** button clears all entries in the marker list of the current channel after confirmation.

The User Marker Panel can be quit as usual with OK or Cancel. When the **Show Marker Graph** button is pressed, the marker characteristics of the four marker channels are graphically displayed.

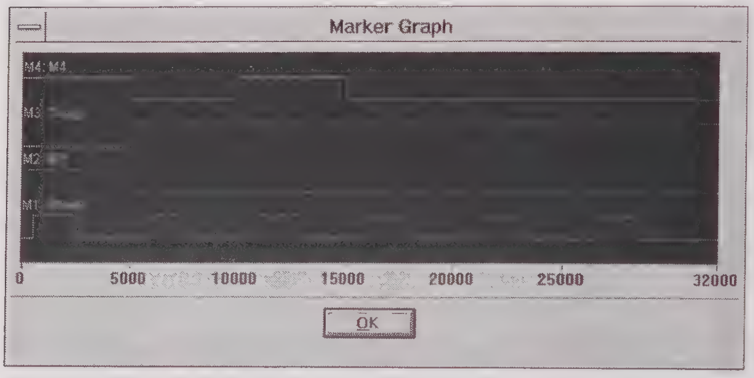


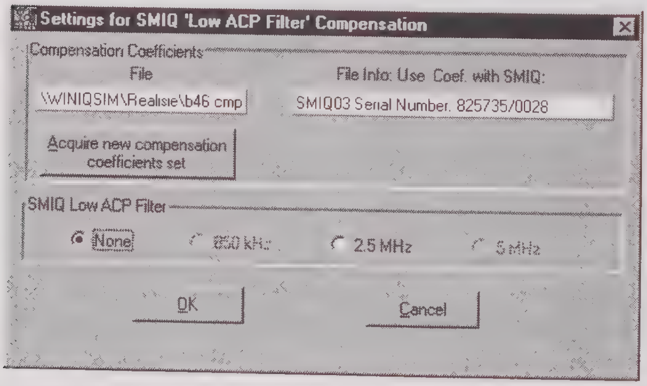
Fig.:5-132 Marker Graph panel

As mentioned before, the marker channels can also be defined in the data editor at data bit level. If desired, settings made there can be automatically converted to the sample level and transferred into the Marker Setting panel. To avoid the positions defined in the data editor being inadvertently overwritten in the Marker Setting panel, the Marker Setting panel is disabled. The marker positions can be viewed but not edited. The Add Marker Point, Delete Marker Point and Reset List buttons are disabled (grey). The message **Defined by data editor** is displayed in the top window of the panel. The **Release** button is also displayed. With this button the Marker Setting panel can be activated again. The marker positions can be edited as usual.

The Marker Setting panel is quit with the **OK** button. When it is quit with the **Cancel** button all the settings made are discarded.

5.25.11 Settings for SMIQ ‘Low ACP Filter’ Compensation Panel

An IQ filter can be activated in SMIQ provided that option SMIQ-B46 (only 2.5 MHz filter) or -B47 (also 0.85 and 5 MHz filters) is built in. This filter is basically used to keep the adjacent channel power low (low ACP). The frequency response or group delay response of these filters can be considered as precorrection in the AMIQ curve and thus be compensated. The required settings can be made in the panel below.


Settings for SMIQ 'Low ACP Filter' Compensation

Compensation Coefficients

File: \WINIQSIM\Realisie\b46.cmp

File Info: Use Coef. with SMIQ: SMIQ03 Serial Number: 825735/0028

SMIQ Low ACP Filter: ● None ○ 850 kHz ○ 2.5 MHz ○ 5 MHz

Fig.: 5-133: Settings for SMIQ ‘Low ACP Filter’ Compensation panel

Compensation Coefficients

File and **File Info: Use Coef. with SMIQ:**
The frequency response and the group delay time of these filters are measured for each SMIQ and entered in the EEPROM of SMIQ by the manufacturer. The values must therefore be first read out by

WinIQSIM and stored in a file. WinIQSIM can handle the compensation coefficients of several SMIQs since they are stored in separate files. Part of each file is the **File Info** providing information about the type and serial number of SMIQ. After selection of the file (field **File)** the file information is updated.

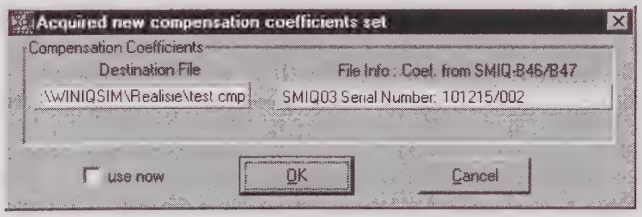
Acquire new compensation coefficients set
This button allows to read out values from SMIQ. A new file selection window is then opened and a file name under which data can be stored can be entered. If a file of the same name is already available, a warning with an overwrite option is output. When pressing **Save,** data from SMIQ are fetched. Depending on the option selected in the SMIQ Interface and Transmission Option panel, the user is asked about the required connection (**SMIQ Connection** GPIB / RS232). After successful transmission, the window **Acquired new compensation coefficients set** is displayed (see below).

SMIQ Low ACP Filter
An IQ filter can be activated in SMIQ provided that option SMIQ-B46 (only 2.5 MHz Filter) or -B47 (also 0.85 and 5 MHz filters) is built in. WinIQSIM reads out the possible types of filter from the selected file. If **no** filter is switched on in SMIQ, select **None** since the calculated curve for AMIQ would be impaired by the precorrection considered. The correct filter in SMIQ can also be switched on automatically if option **use SMIQ connection (for auto set)** has been selected in the **SMIQ Interface and Transmission Options** panel.

The panel is quit with the **OK** button. When the **Cancel** button is pressed, all settings made are discarded.

5.25.11.1 Acquired New Compensation Coefficients Set

The file name entered under **Destination File** and the **File Info** stored, ie SMIQ type and serial number are displayed here. With the **Cancel** button, the action is quit. With the OK button, data are stored. Option **use now** determines whether the file just generated is to be indicated in the output window **Settings for SMIQ Low ACP-Filter Compensation** ie to be used for the calculation of the curve.


Acquired new compensation coefficients set
Compensation Coefficients
OK
Cancel

Destination File: :\WINIQSIM\Realisie\test cmp

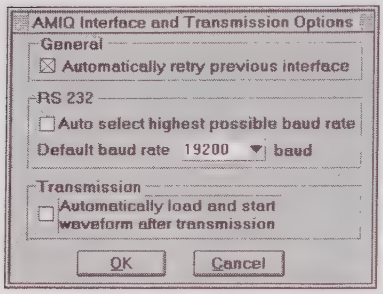
File Info : Coef. from SMIQ-B46/B47: SMIQ03 Serial Number: 101215/002

☐ use now

Fig.:5-134 Acquired new compensation coefficients set window

5.25.12 AMIQ Interface and Transmission Options Panel

In this panel, all options concerning the AMIQ interface (GPIB/IEEE 488.2 or RS-232) and data transmission can be set.



AMIQ Interface and Transmission Options

General

☒ Automatically retry previous interface

RS 232

☐ Auto select highest possible baud rate

Default baud rate 19200 baud

Transmission

☐ Automatically load and start waveform after transmission

Fig.:5-135 AMIQ Interface and Transmission Options panel

General
When an action requires a connection to AMIQ (AMIQ remote control or data transmission) and the **Automatically retry previous interface** option is selected, an attempt is automatically made to set up such a connection via the interface and address used for the last successful connection. Thus the interface and GPIB/IEEE 488.2 address of AMIQ need not be selected each time communication to an AMIQ with the same interface/address has to be established. If connections are required to different AMIQs, this option should be switched off to avoid the previous connection to AMIQ being automatically restored.

RS 232
With the **Auto select highest possible baud rate** option selected, WinIQSIM attempts to set the maximum baud rate when a connection to AMIQ is established via the serial interface. This allows to reduce the transmission time to a minimum without the need to check the highest baud rate of your PC.
If this option is not selected, the rate set in the **Default baud rate** field is used whenever a serial connection is established. A rate of 1200, 2400, 4800, 9600, 19200, 38400, 57600 or 115200 baud can be set. A connection can only be established when the corresponding baud rate is selected in the AMIQ. WinIQSIM determines the baud rate selected in AMIQ and switches to the default baud rate.

Possible problem:

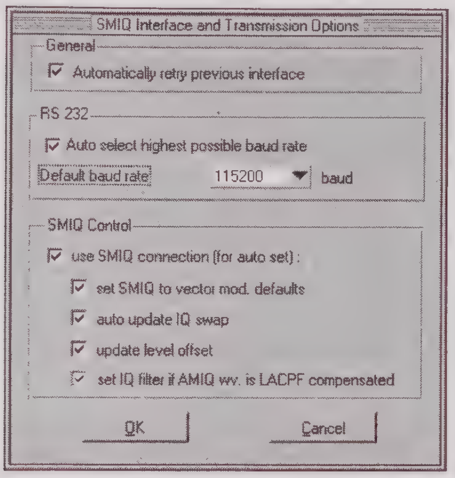
With some PCs and operating systems the maximum baud rate of AMIQ (115200 baud) cannot be set. If however the baud rate of AMIQ was set to 115200 baud and the PC cannot set this rate, WinIQSIM cannot establish a connection to AMIQ via RS232. In this case, the baud rate of AMIQ can be changed with the aid of a floppy disk with a text file containing the command **:SYST:COMM:SER:BAUD 19200**. The file on the floppy must be designated autoexec.iec. Switch off AMIQ, insert the floppy and switch on AMIQ. The new baud rate is automatically set.

Transmission
With the **Automatically load and start waveform after transmission** option selected, an I/Q waveform file transmitted to the AMIQ is automatically loaded into the output buffer and signal output is started (provided the destination for the transmission was not the RAM). Thus the new signal can be used immediately after transmission without the need to call the AMIQ Remote Control menu.

The panel is quit with the **OK** button. When the **Cancel** button is pressed all settings made are discarded.

5.25.13 SMIQ Interface and Transmission Options Panel

In this panel, all options concerning the SMIQ interface (GPIB/IEEE 488.2 or RS-232) and data transmission can be set.



SMIQ Interface and Transmission Options

General

☑ Automatically retry previous interface

RS 232

☑ Auto select highest possible baud rate

Default baud rate 115200 baud

SMIQ Control

☑ use SMIQ connection (for auto set) :
  ☑ set SMIQ to vector mod. defaults
  ☑ auto update IQ swap
  ☑ update level offset
  ☑ set IQ filter if AMIQ wv. is LACPF compensated

Fig.:5-136 SMIQ Interface and Transmission Options panel

General
When an action requires a connection to SMIQ (SMIQ remote control or data transmission) and the **Automatically retry previous interface** option is selected, an attempt is automatically made to set up such a connection via the interface and address used for the last successful connection. Thus the interface and GPIB/IEEE 488.2 address of SMIQ need not be selected each time communication to an SMIQ with the same interface/address has to be established. If the interface or its settings are changed, this option should be switched off since the previous connection would otherwise be set.

RS 232
With the **Auto select highest possible baud rate** option selected, WinIQSIM attempts to set the maximum baud rate with a connection made to SMIQ via the serial interface. This allows the transmission time to be reduced to a minimum without the need to check the highest baud rate of your PC.
If this option is not selected, the rate set in the **Default baud rate** field is used whenever a serial connection is established. A rate of 1200, 2400, 4800, 9600, 19200, 38400, 57600 or 115200 baud can be set. A connection can only be made when the corresponding baud rate is selected in the SMIQ. WinIQSIM determines the baud rate selected in SMIQ and switches to the default baud rate.

Possible problem:

With some PCs and operating systems the maximum baud rate of SMIQ (115200 baud) cannot be set. If the baud rate of SMIQ is nevertheless set to 115200 baud and the PC cannot set this rate, WinIQSIM will not be able to establish a connection to SMIQ via RS232. In this case, the baud rate of SMIQ can be changed manually (menu UTILITIES: SYSTEM: RS232).

SMIQ Control

use SMIQ connection (for auto set)
With WinIQSIM, SMIQ can be controlled automatically in some functions. This may be useful in conjunction with AMIQ. Whether WinIQSIM should attempt to set up a remote-control connection to SMIQ can be selected with this option. The following options are possible:

set SMIQ to vector mod. defaults
If a curve is started in AMIQ (can also be done when the curve is loaded automatically), this option determines whether SMIQ is set to the vector modulation mode. All other modulations are switched off (from SMIQ version 3.85 or higher), both the Impairment State and the IQ Swap Mode are set to off.

auto update IQ swap
Depending on the I/Q modulator model used in the receiver, the IQ SWAP parameter must be activated in the VECTOR MOD menu of SMIQ (see section 5.25.1). This parameter can be automatically set in the waveform file of the AMIQ output memory, depending on the entry made.
With the **auto update IQ swap** option active, the IQ SWAP parameter is automatically set in the AMIQ upon loading, depending on the selected trace (same as with trace transmission in the Transmission panel).

update level offset
The power offset is the difference as specified by modulation between the effective power at full-scale level and the carrier power with modulation (see chapter Signal Statistics and Quantization). It is calculated during the generation of the AMIQ curve and can be set as an offset in SMIQ or automatically transmitted to SMIQ with this option. SMIQ then always displays the effective power at the output as level.

set IQ filter if AMIQ wv is LACPF compensated
An IQ filter can be activated in SMIQ provided that option SMIQ-B46 (only 2.5 MHz Filter) or -B47 (also 0.85 and 5 MHz filters) is built in. This filter is basically used to keep the adjacent channel power low (Low ACP). The frequency response or group delay response of these filters can be considered as precorrection in the AMIQ curve and thus be compensated. If this precorrection is considered, the corresponding filter is switched on in SMIQ. This option cannot be switched off. It is only effective if option **use SMIQ connection (for auto set)** is switched on. A warning is displayed if the curve is not compensated but the filter is switched on in SMIQ.

The panel is quit with the **OK** button. When the **Cancel** button is pressed all settings made are discarded.

Note: *If the low ACP compensation functionality in WinIQSIM is to be used for externally generated IQ signals, proceed as follows:*

- Call up software AMIQ-K2 delivered with AMIQ (also available via Rohde & Schwarz homepage on the Internet http://www.rsd.de).
- Select the externally generated I/Q waveform file as source and press the **Transmit** button.
- Select option **WinIQSM *.ibn File** in the Store Converted Data panel then opened and enter a target file in which the external signal is to be stored in WinIQSIM format (for further details see AMIQ-K2 manual). Start conversion by pressing the **OK** button.
- Select the multicarrier mixed signal system in WinIQSIM
- In Carrier Settings panel set 1 for No. of carriers and 0 kHz as carrier spacing and 1 as superoversampling. Then assign the WinIQSIM *.ibn file just generated with AMIQ-K2 to the only carrier (see also chapter 10).
- The low ACP functionality of WinIQSM can now be used as described above.

5.25.14 Several Controllers on the Bus/AMIQ Controlled from Signal Generator SMIQ

Since AMIQ has no control elements and displays, it is remote-controlled either from Signal Generator SMIQ or WinIQSIM software via IEC/IEEE bus. The controlling device – either the PC (with WinIQSIM) or SMIQ – must therefore be the controller on the IEC/IEEE bus. If all three devices are connected to the same bus, there will be problems if the two controlling devices want to be the controller on the bus at the same time which is not allowed by the bus specification.

There will be no conflicts if WinIQSIM or SMIQ alone is used to control the AMIQ. Where **alternate control** is desired, eg loading of a waveform from WinIQSIM and control from SMIQ, the user must first leave the control menus of the other controlling device for abandoning the controller function. On the SMIQ, this is the AMIQ CTRL menu (with the control elements of AMIQ) that must be closed and for the WinIQSIM program it is the menu AMIQ -> Remote Control and BERT. In the latter case it also has to be ensured that the data transmission activated by AMIQ -> TRANSMISSION is completed since only then can the controller function be quit. If there are any bus conflicts, the error message 'IEC-timeout' will be output on the SMIQ and the 'Communication to AMIQ (GPIB) failed' message with WinIQSIM as soon as the remote-control menus are called up.

Problems may occur however in systems where for instance the SMIQ is to control the AMIQ and the **SMIQ** itself is to be **controlled** by a (system) **controller**. In this case, the SMIQ cannot become the controller (in charge) which is a prerequisite for controlling the AMIQ. This means that the controller of the SMIQ has to quit its control function. Usually, this case will not be considered in the (system) control programs. It is not at all sure whether upon completion of these programs the bus interface will be set to passive state.

If upon the attempt to use one of the commands of the AMIQ CTRL menu the SMIQ outputs the **error message** 'IEC-timeout' and there is a controller on the bus which might be used as an IEC/IEEE bus controller, the problem can be overcome by using the GPIB cards from National Instruments (NI) and their software drivers: after quitting the control program, the interactive control program of NI that is available both under DOS and Windows can be used. All that has to be done is to enter the two command lines

```
ibfind gpib0
ibonl 0
```

and to quit the program with 'q'. The program's name is IBIC.EXE under DOS, in the Windows versions it can be found in the 'NI-488.2 GPIB Software' group (... Interactive Control). A maximum of 4 GPIB cards from NI can be integrated in a controller, so it is necessary to include a command for deactivating the cards that are not to be used. Therefore, the first command line must be

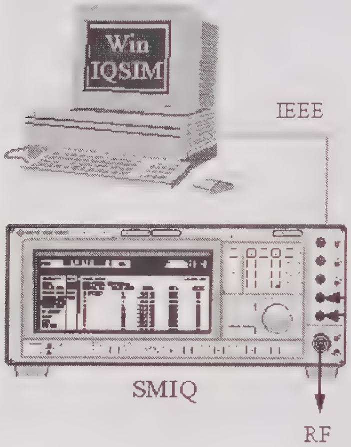
```
ibfind gpib0, ibfind gpib1,  ibfind gpib2 or ibfind gpib3.
```

The card's assignment has been defined by NI in the configuration program and can be checked with this program ('IBCONF' in DOS or 'Configuration' or simply 'GPIB' in the system control of the Windows versions).

5.26 Menu Item SMIQ (ARB)

The system consisting of the SMIQ as vector signal generator and the option SMIQ B60 Arbitrary Waveform Generator as source for baseband signals and WinIQSIM for configuration of the signal data permits to easily generate any complex, digitally modulated communication signals.

Using WinIQSIM, calculated signals can be transferred via IEC bus or RS232 interface to the SMIQ. In addition, an extra control menu under WinIQSIM also permits to set the ARB functions.



The menu item SMIQ (ARB) comprises all functions required for transmitting IQ data to the SMIQ, control of the ARB functions of the SMIQ and configuring the transmission interface. The individual submenus with the associated setting panels are described in the following.

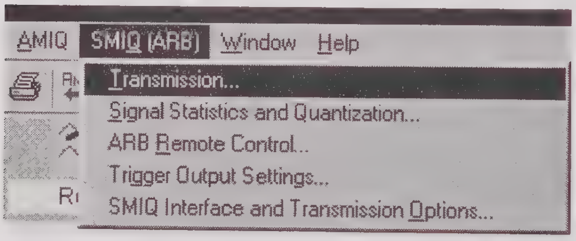
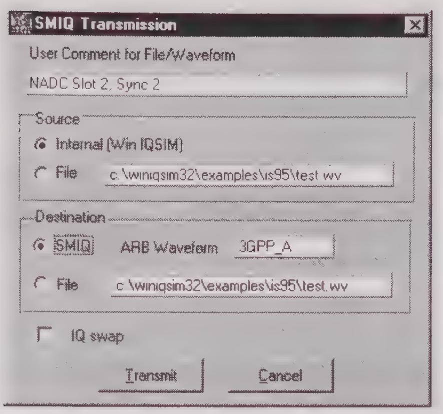

AMIQ
SMIQ (ARB)
Window
Help
Transmission...
Signal Statistics and Quantization...
ARB Remote Control...
Trigger Output Settings...
SMIQ Interface and Transmission Options...

Fig.: 5-137 Menu SMIQ (ARB)

5.26.1 SMIQ Transmission Panel

The SMIQ transmission panel is the interface for transmission of calculated IQ data to the SMIQ as waveform. As an alternative, data can be transmitted via the GPIB/IEEE 488.2 bus or the RS232 interface.

The SMIQ Transmission panel comprises three windows. In the first a comment on the current waveform can be entered. This comment can subsequently be read out of the SMIQ for simplifying selection and management of the IQ signal data in the SMIQ. In the second window a selection can be made whether the IQ signal generated in WinIQSIM or a waveform file stored on the hard disk of your PC should be transmitted. In the last panel the destination of the transmission is selected. The IQ signal data can be stored as waveform in the SMIQ or on floppies or on the hard disk of your PC.



User Comment for File/Waveform: NADC Slot 2, Sync 2

● Internal (Win IQSIM)
○ File c:\winiqsim32\examples\is95\test.wv

● SMIQ ARB Waveform 3GPP_A
○ File c:\winiqsim32\examples\is95\test.wv

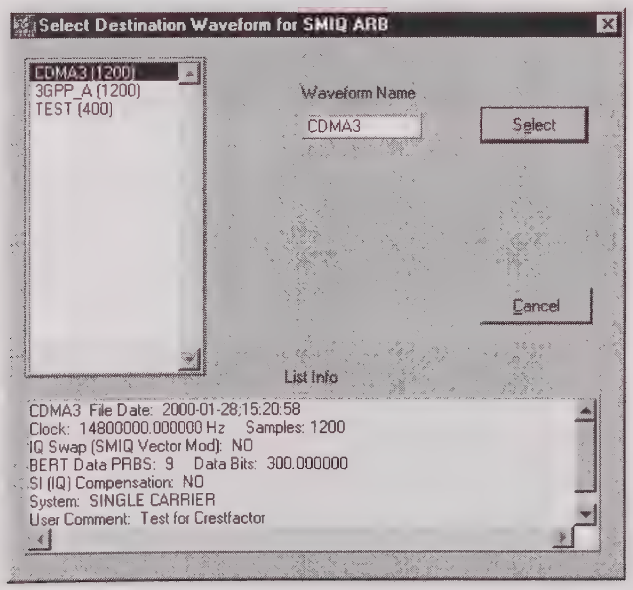
☐ IQ swap

Fig.: 5-138 Transmission panel

User Comment for File/Waveform
In this field a comment of up to 79 characters on the current IQ signal can be entered. This comment is stored together with the IQ data and can subsequently be read out of SMIQ to simplify selection and management of waveform files in the SMIQ.

Source
In this window a selection can be made whether the IQ signal defined by WinIQSIM (**Internal**) or a signal file (**File**) previously stored on the hard disk of your PC should be transmitted. In the File selection field the currently selected source file is displayed. To select another source file click into the field with the left mouse key. A file selection window is opened where a file with the extension ***.wv** (waveform) can be selected for transmission.

Destination
In this window the destination of the transmission is set. The selected waveform can be directly transmitted to the SMIQ (**SMIQ**). There it is stored under the name entered in the field **ARB Waveform**. When clicking into this field, a window is opened where the waveform name can be determined in the SMIQ.



CDMA3 (1200)
3GPP_A (1200)
TEST (400)

Waveform Name: CDMA3

```
CDMA3  File Date:  2000-01-28;15:20:58
Clock:  14800000.000000 Hz    Samples: 1200
IQ Swap (SMIQ Vector Mod):  NO
BERT Data PRBS:  9    Data Bits:  300.000000
SI (IQ) Compensation:  NO
System:  SINGLE CARRIER
User Comment:  Test for Crestfactor
```

Fig.: 5-139 Panel for selection of a waveform name for the SMIQ ARB

You can select an already existing waveform, which will then be overwritten after a warning, or enter a new name in the field **Waveform Name** (max. eight characters). The **Select** button confirms your choice. The Info window displays some information on the waveform selected in the name field. The meaning of the parameters can be obtained from the paragraph Select/Delete Waveform in the section SMIQ ARB Remote Control.5.26.3.

You can also store a calculated signal file on the hard disk of your PC (**File**) for later transmission to the SMIQ. The field to the right of this item displays the current destination file. A file with the extension ***.wv** (waveform) can be selected here for storage of the signal.

IQ swap

Unfortunately, there is no worldwide uniform definition of an I/Q modulator. For instance, the IQ modulator defined in the IS2000 standard (CDMA2000) differs from that of WinIQSIM and SMIQ.

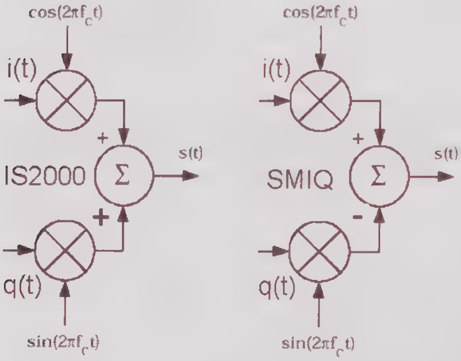


Fig.: 5-140 Definition IQ Modulator in IS2000 and WinIQSIM/SMIQ

As defined by IS2000, the RF signal s(t) is obtained from the baseband IQ signal as follows:

$$s(t) = i(t)\cos(2\pi f_c t) + q(t)\sin(2\pi f_c t)$$

The following definition is used in SMIQ and WinIQSIM:

$$s(t) = i(t)\cos(2\pi f_c t) - q(t)\sin(2\pi f_c t)$$

To enable an I/Q demodulator defined to IS2000 to cope with an RF signal generated by SMIQ, the following has to be observed:

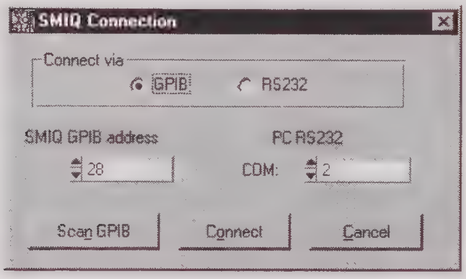
- **Generation of RF signals with SMIQ**
  The I/Q SWAP parameter in the VEKTOR MOD menu must be ON to be compatible with the IS2000 IQ Modulator definition.

The **IQ swap** parameter causes a note to be made in the signal file transferred to the SMIQ whether IQ swap is to be used or not. The RF signal can thus be individually adapted to your IQ modulator/demodulator model.

5.26.1.1 Signal Transmission

The selected transmission mode is started with the **Transmit** button. The transmission procedure for the various combinations of source and destination is described below.

Source Internal ⇒ SMIQ
The signal configured by WinIQSIM is transmitted to the waveform pool of the SMIQ. In a first step, WinIQSIM establishes a connection to the SMIQ. If **Automatically retry previous interface** is selected in the **Interface and Transmission Options** panel, an attempt is made to access SMIQ under the address / interface used for the last successful transmission. If this attempt fails or if the option is not selected in the Interface and Transmission Options panel, the following panel will be displayed.


SMIQ Connection

Connect via: ● GPIB ○ RS232

SMIQ GPIB address: 28

PC RS232 COM: 2

Fig.: 5-141 SMIQ Connection panel

Here the interface (GPIB/IEEE 488.2 or RS232) and the address for the desired SMIQ connection can be selected. If your SMIQ is connected to the GPIB/IEEE 488.2 bus and you do not know its address, an automatic search for SMIQ can be triggered with the Scan GPIB button.

With the connection to SMIQ established, the IQ signal is calculated as configured. This step is omitted when the calculation has been performed before, eg for a graphics display.

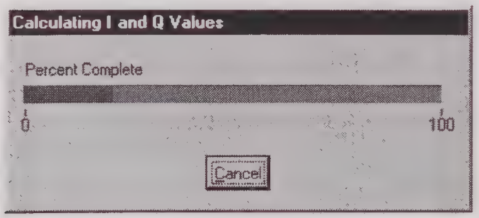
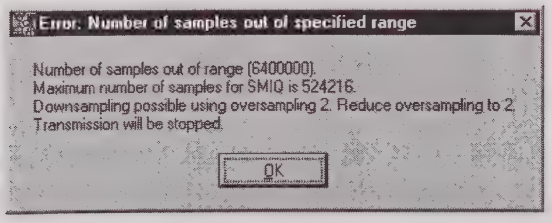

Calculating I and Q Values

Fig.: 5-142 Progress indication during calculation of the IQ values

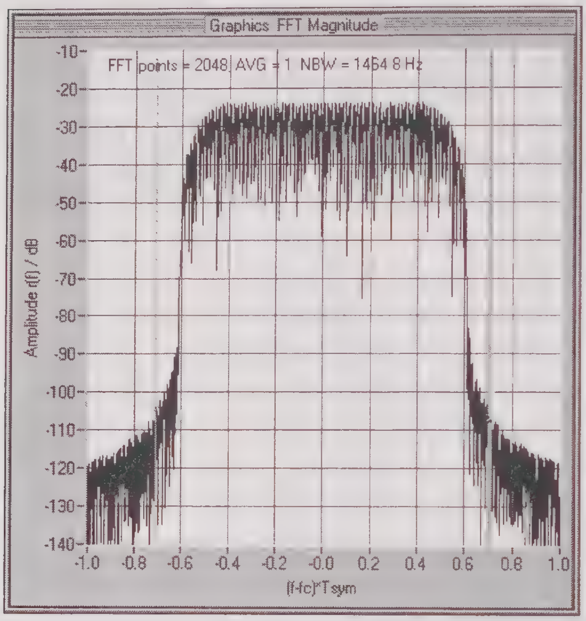
If, after the calculation, the number of samples is found to be greater than the maximum permissible number for the SMIQ, an error message will be output. If you have set oversampling to >2, you may now repeat the calculation with oversampling 2. The same procedure is possible if the maximum output clock rate of the SMIQ is exceeded.

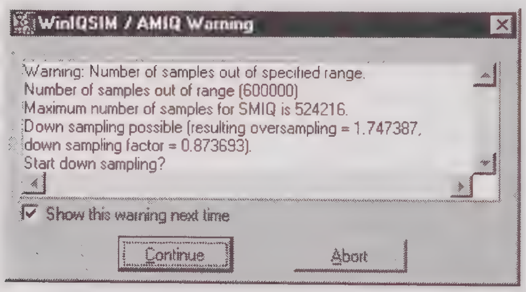

Error: Number of samples out of specified range

Number of samples out of range (6400000).
Maximum number of samples for SMIQ is 524216.
Downsampling possible using oversampling 2. Reduce oversampling to 2.
Transmission will be stopped.

Fig.: 5-143 Example of error message when the maximum possible number of samples is exceeded

If the number of samples is still to high with oversampling 2, WinIQSIM will try to reduce the number by down sampling . Make sure that there are no useful components of the signal outside the new frequency range produced by down sampling, which is the case with the down sampling offered by WinIQSIM with W-CDMA and CDMA2000. For this purpose, the graphics display FFT-MAGnitude can be used (Setting Freq/Time: Norm). The useful spectrum must lie between –Oversampling/2 and +Oversampling/2. In the following example, the cursors point to values below –80 dB at the frequencies obtained with a downsampling of 1.5.





Warning: Number of samples out of specified range.
Number of samples out of range (600000)
Maximum number of samples for SMIQ is 524216.
Down sampling possible (resulting oversampling = 1.747387,
down sampling factor = 0.873693).
Start down sampling?

☑ Show this warning next time

Fig.: 5-144 Warning when reducing the number of samples

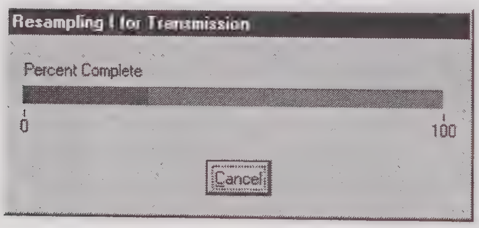


Fig.: 5-145 Progress indication when reducing the number of samples

If, with the current settings, there is the risk of the signal values being clipped or the SMIQ being overdriven, the **Signal Statistics and Quantization** panel will appear. This panel described in section **5.26.2** shows data on the signal statistics and permits to influence the conversion of the IQ values from WinIQSIM to the transmission format of the SMIQ.

The calculated IQ values are now converted into the SMIQ format (16 bits for I and Q each, which are, however, not identical with the output resolution of the SMIQ). During this procedure, the following progress indication will appear:

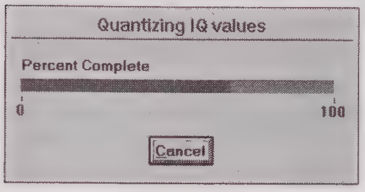


Fig.: 5-146 Progress indication during conversion of the IQ values to SMIQ format

After conversion of the IQ values, the IQ waveform is transferred to the SMIQ. The window below informs on the progress of transmission.

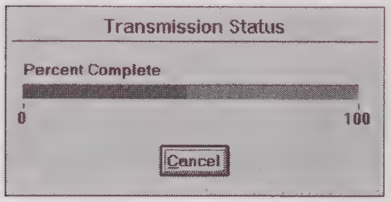


Fig.: 5-147 Progress indication for transmission of IQ values to SMIQ

After data transmission to the SMIQ has been completed, correct reception of the data is checked with the aid of a check sum. If an error is detected in the SMIQ, a respective message is entered in the error queue. After the transmission, WinIQSIM reads out the error queue and informs the operator on problems, if any. If no error occurred, no message is output.

When the **After transmission: Automat. select Waveform. After selection: Automat. set ARB state to ON** option has been selected in the **SMIQ Interface and Transmission Options** panel, the output of the transmitted signal is started in the SMIQ.

Source Internal ⇒ File
The signal currently configured by WinIQSIM is stored in a file on the hard disk of your PC or on a floppy.

The file name and the path where the signal should be stored can be selected in the field to the right of the **Destination: File** window.

Pressing the **Transmit** button starts the calculation of the IQ signal. If signal values are likely to be clipped or overdriven because of the current setting, the **Signal Statistics and Quantization Panel** is opened. This panel described in section 5.26.2 provides information on signal statistics and permits to influence the conversion of IQ values from WinIQSIM to the SMIQ transmission format.

The calculated IQ values are converted to the SMIQ format.

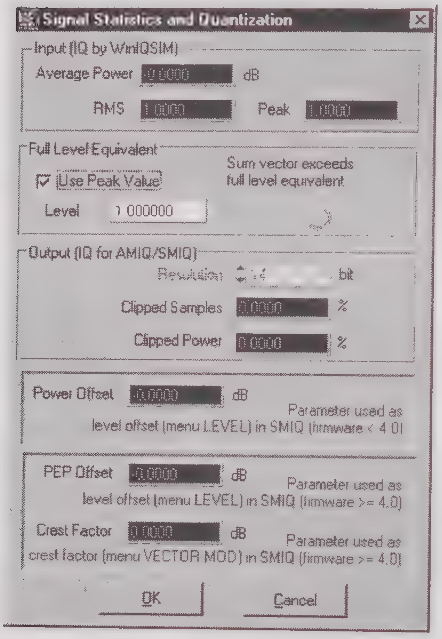
After the conversion, the I/Q waveform is stored on your PC.

Source File ⇒ SMIQ / Source File ⇒ File
Transmission from a source file is similar to the procedure described for a transmission from an internal source. The difference is that calculation of the I/Q display, display of the signal statistics and Quantization panel and conversion to the SMIQ format are not required.

The file containing the signal to be transmitted can be selected in the field to the right of the **Source: File** window.

5.26.2 SMIQ Signal Statistics and Quantization Panel

The IQ signal is calculated by WinIQSIM as a sequence of floating-point numerals. Before the transmission to the SMIQ the signal has to be converted to the SMIQ integer format. The user can specify an IQ signal level in WinIQSIM that corresponds to full-scale level in the SMIQ. For determining this signal level, a few statistical parameters of the I/Q signal calculated by WinIQSIM are displayed in the upper window of this panel.


Signal Statistics and Quantization
Input (IQ by WinIQSIM)
Full Level Equivalent
Sum vector exceeds full level equivalent
Output (IQ for AMIQ/SMIQ)
Parameter used as level offset (menu LEVEL) in SMIQ (firmware < 4.0)
Parameter used as level offset (menu LEVEL) in SMIQ (firmware >= 4.0)
Parameter used as crest factor (menu VECTOR MOD) in SMIQ (firmware >= 4.0)
OK
Cancel

Average Power 0.0000 dB

RMS 1.0000

Peak 1.0000

☑ Use Peak Value

Level 1.000000

Resolution 14 bit

Clipped Samples 0.0000 %

Clipped Power 0.0000 %

Power Offset 0.0000 dB

PEP Offset 0.0000 dB

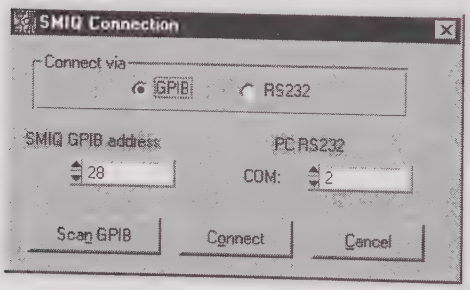
Crest Factor 0.0000 dB

Fig.: 5-148 Signal Statistics and Quantization panel

These panels are completely described in chapter Signal Statistics and Quantization in the AMIQ part. Only the input of the resolution is different. For the SMIQ it is 16 bits for the transmission (not identical with output resolution) and cannot be changed.

5.26.3 SMIQ ARB Remote Control Panel

To allow remote control of the SMIQ, a connection to the SMIQ (GPIB/IEEE 488.2 or RS232) has to be set up first. If **Automatically retry previous interface** has been selected in **Interface and Transmission Options** panel, an attempt is made to access SMIQ under the address/interface used for the last successful connection. If this attempt fails or if the option is not selected in the Interface and Transmission Options panel, the following panel is displayed.



● GPIB ○ RS232

SMIQ GPIB address 28

PC RS232 COM: 2

Fig.: 5-149 SMIQ Connection panel

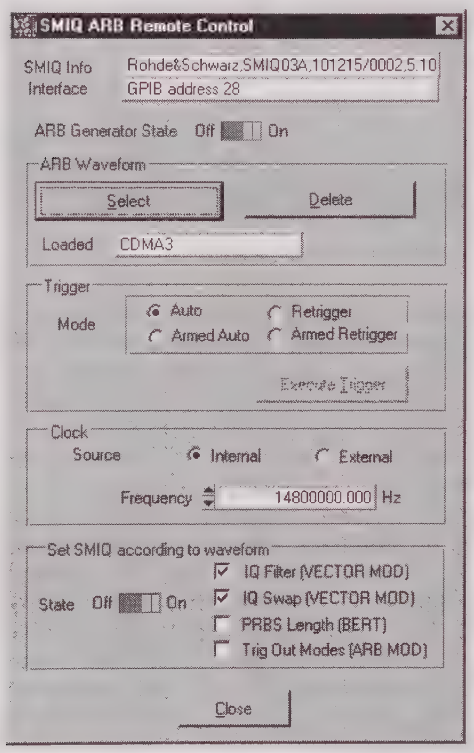
Here the interface (GPIB/IEEE 488.2 or RS232) and the address for the desired SMIQ connection can be selected. If your SMIQ is connected to GPIB/IEEE 488.2 bus and you do not know its address, an automatic search for SMIQ can be triggered with the Scan GPIB button.

Note *The PC on which WinIQSIM is installed must be the controller on the GPIB/IEEE bus. In case of any problems refer to chapter "Several Controllers on the Bus".*

After the connection to SMIQ has been established, the **SMIQ ARB Remote Control** panel is displayed.

The device identification of SMIQ (answer to query "*idn?") is displayed in the **SMIQ Info** field.
It has the following syntax: "**Rohde&Schwarz, SMIQ, ssssss/sss, x.yy**" with ssssss/sss being the serial number and x.yy the software version.

The interface via which the communication with SMIQ takes place (GPIB or RS232) and the address of the SMIQ with GPIB (Default 28) or the baud rate used with RS232 are displayed in the **Interface** field.



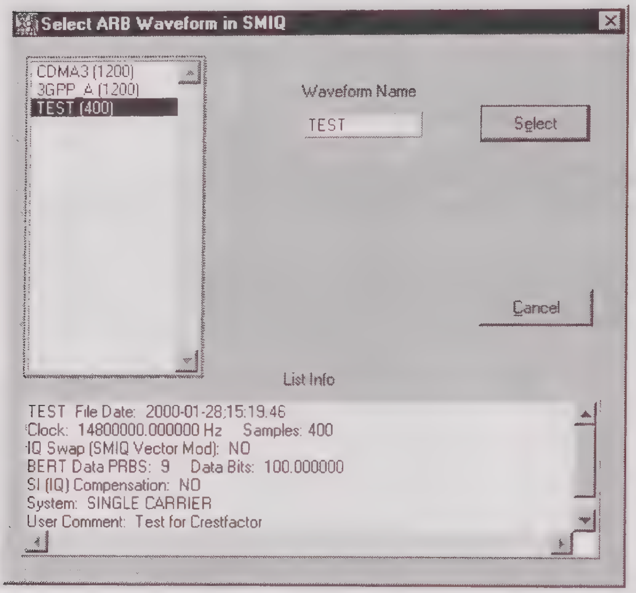
SMIQ Info: Rohde&Schwarz,SMIQ03A,101215/0002,5.10
Interface: GPIB address 28
ARB Generator State: Off / On
Loaded: CDMA3
Mode: ● Auto ○ Retrigger ○ Armed Auto ○ Armed Retrigger
Source: ● Internal ○ External
Frequency: 14800000.000 Hz
State: Off / On
☑ IQ Filter (VECTOR MOD)
☑ IQ Swap (VECTOR MOD)
☐ PRBS Length (BERT)
☐ Trig Out Modes (ARB MOD)

Fig.: 5-150 SMIQ Remote Control panel

ARB Waveform
In this window, an IQ waveform file can be selected and then loaded into the output memory of the SMIQ or deleted. Pressing the **Select** or **Delete** button opens a **Waveform selection window**.

In the **Loaded** field, the signal file currently loaded in the output memory of the SMIQ is specified.

Waveform window Select



CDMA3 (1200)
3GPP_A (1200)
TEST (400)

Waveform Name: TEST

```
TEST  File Date:  2000-01-28;15:19.46
Clock:  14800000.000000 Hz     Samples: 400
IQ Swap (SMIQ Vector Mod):  NO
BERT Data PRBS:  9     Data Bits:  100.000000
SI (IQ) Compensation:  NO
System:  SINGLE CARRIER
User Comment:  Test for Crestfactor
```

Fig.: 5-151 Panel for selection of a waveform in SMIQ

In this window a waveform to be loaded into the SMIQ output memory can be selected. All waveform files included in the SMIQ are then listed at the left. Here a waveform can be selected with the left mouse key. Further information on the selected waveform is displayed in the Info field. Confirm your choice with the **Select** button. The waveform is then loaded into the SMIQ. The selection can be aborted with the **Cancel** button.

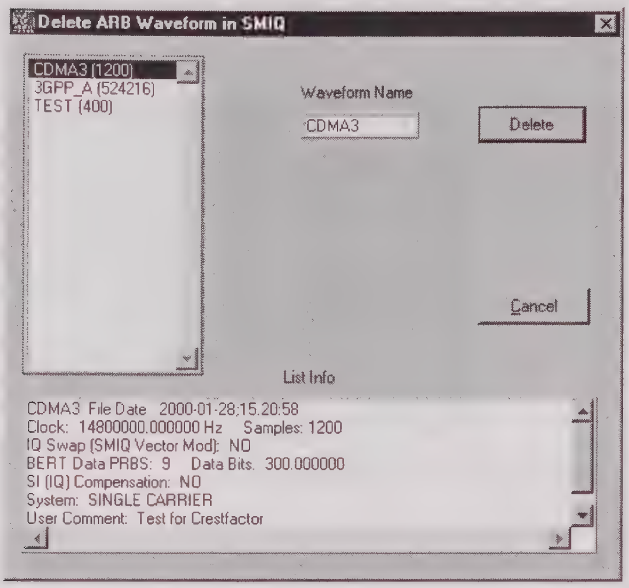
The waveform length in samples in indicated in brackets after the waveform names.

Some information on the selected waveform file is displayed in the **Info** field. The following parameters can be indicated

- **Date** and time,
- the notation **IF Signal** in the case of IF signals
- **Clock** for waveform output and number of samples,
- whether the data for swapped IQ signals has been calculated (**IQ Swap**),
- if the waveform for BER measurement is prepared: type of PRBS (**BERT Data PRBS**) and number of data bits (**Data Bits**) in the waveform,
- whether an **SI (IQ) Compensation** has been taken into account in the waveform,
- the system used to generate the signal in WinIQSIM (Single Carrier, Multi Carrier, 3 GPP W-CDMA, IS 95, CDMA2000 or Import),
- user **Comment** on the waveform entered in the Transmission panel prior to transmission.

This function simplifies management and selection of waveform files by providing further information in addition to the 8-character file name.

Waveform window for Delete



CDMA3 (1200)
3GPP_A (524216)
TEST (400)

Waveform Name: CDMA3

```
CDMA3  File Date   2000-01-28;15.20:58
Clock:  14800000.000000 Hz    Samples: 1200
IQ Swap (SMIQ Vector Mod):  NO
BERT Data PRBS:  9    Data Bits.  300.000000
SI (IQ) Compensation:  NO
System:  SINGLE CARRIER
User Comment:  Test for Crestfactor
```

Fig.: 5-152 Panel for selecting a waveform for deletion

The structure corresponds to that of the Select Panel. By pressing the Delete button, the waveform is deleted in the SMIQ after output of a warning.

Trigger
In this window, the sequence control of ARB mode is configured. In the case of **Auto** the waveform is immediately output and cyclically repeated. With **Retrig** each trigger event causes a new start. **Armed Auto** requires a trigger event for the start. Further trigger events are ignored. **Armed Retrigger** corresponds to Armed Auto, except that each further trigger event causes a new start.

Clock
This panel permits to set the clock source and the clock frequency. Either an **Internal** or an **External** clock generator can be selected. With **Frequency** you can set the clock. Even if an external clock source is used, the applied frequency must be entered here. Since the waveform in the SMIQ must be readapted each time the frequency is changed, it takes a few seconds until the signal is applied at the SMIQ.

Set SMIQ according to waveform
A few SMIQ setting values are closely linked with the waveform. You may select whether these SMIQ settings are to be performed automatically or not each time a waveform is loaded. If **State** is set to **OFF**, no settings are changed, irrespective of the parameter settings described below.

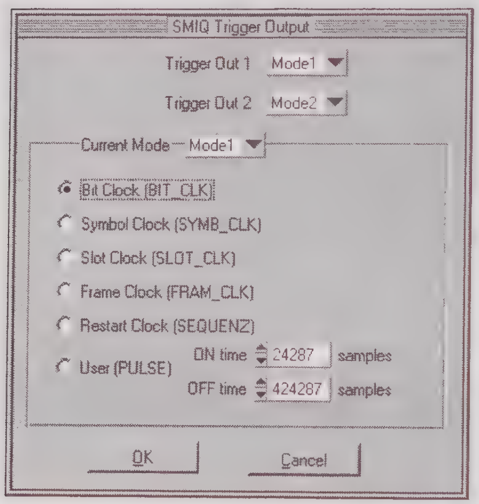
If **IQ Filter** is set, the setting of the respective parameter is changed in the VECTOR MOD menu of the SMIQ if a setting is required in the loaded waveform. In the case of waveforms calculated specially for SMIQ the IQ filter is not taken into account and can therefore be freely changed on the SMIQ.

IQ Swap swaps the IQ signals via an SMIQ setting in the VECTOR MOD menu of the SMIQ. If a swap is required for a waveform calculated for a particular standard, this setting should be selected. By setting this field, the swap is performed automatically by the SMIQ when a waveform is loaded.

PRBS Length automatically sets the type of the PRBS in the BERT menu (Option SMIQ B21) if the waveform has been prepared for a BER measurement in WinIQSIM.

If **Trig Out Mode** is set, the parameters TRIGGER OUT1 MODE and TRIGGER OUT2 MODE are set in the SMIQ menu ARB MOD under TRIGGER....to the values set for this purpose in WinIQSIM in the Panel Trigger Output Settings.

5.26.4 SMIQ Trigger Output Settings Panel



Trigger Out 1 Mode1

Trigger Out 2 Mode2

Current Mode Mode1

● Bit Clock (BIT_CLK)

○ Symbol Clock (SYMB_CLK)

○ Slot Clock (SLOT_CLK)

○ Frame Clock (FRAM_CLK)

○ Restart Clock (SEQUENZ)

○ User (PULSE) ON time 24287 samples, OFF time 424287 samples

Fig.: 5-153 Panel for setting the trigger outputs

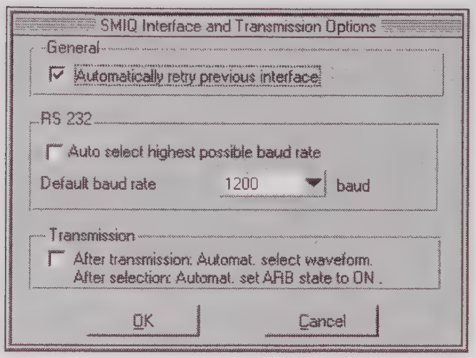
The trigger outputs of the SMIQ are controlled by counters operated by the sample clock. Depending on the system, WinIQSIM can calculate values for the ON and OFF time counter and transfer them together with the waveform. Up to 4 pairs of values are possible in the SMIQ which is why there are 4 modes in the WinIQSIM panel. A mode can be assigned to the first trigger output with **Trigger Out1** and to the second trigger output with **Trigger Out2**. The function assigned to the 4 modes can be selected in the section **Current Mode**. Since not all modes can always be provided for all systems, only Restart Clock (SEQUENCE) may be available.

Explanation:

BIT_CLK	Edge at the beginning of each bit
SYMB_CLK	Edge at the beginning of each modulation symbol
SLOT_CLK	Edge at the beginning of each slot
FRAM_CLK	Edge at the beginning of each frame
SEQUENZ	Edge at the beginning of each sequence (e.g. as restart signal for BERT)
USER	The user defines a pulse wit the **ON** and **OFF time** parameters.

5.26.5 SMIQ Interface and Transmission Options Panel

In this panel, all options concerning the interface to the SMIQ (GPIB/IEEE 488.2 or RS-232) and data transmission can be set.



☑ Automatically retry previous interface

☐ Auto select highest possible baud rate

Default baud rate 1200 baud

☐ After transmission: Automat. select waveform.
After selection: Automat. set ARB state to ON .

Fig.: 5-154 SMIQ Interface and Transmission Options panel

General
When an action requires a connection to SMIQ (SMIQ remote control or data transmission) and the Option **Automatically retry previous interface** option is selected, an attempt is automatically made to set up a connection via the interface and address used for the last successful connection. Thus the interface and GPIB/IEEE 488.2 address of the SMIQ need not be selected each time communication to an SMIQ with the same interface/address has to be established. If connections are required to different SMIQs, this option should be switched off to avoid the previous connection to SMIQ being automatically restored.

RS 232
With the **Auto select highest possible baud rate** option selected, WinIQSIM attempts to set the maximum baud rate when a connection to SMIQ is established via the serial interface. This allows to reduce the transmission time to a minimum without the need to check the highest baud rate of your PC.

If this option is not selected, the rate set in the **Default baud rate** field is used whenever a serial connection is established. A rate of 1200, 2400, 4800, 9600, 19200, 38400, 57600 and 115200 baud can be set. A connection can only be established when the corresponding baud rate is selected in the SMIQ. WinIQSIM determines the baud rate selected in the SMIQ and switches to the default baud rate.

Possible problem:

With some PCs and operating systems the maximum baud rate of SMIQ (115200 baud) cannot be set. If however the baud rate of the SMIQ was set to 115200 baud and the PC cannot set this rate, WinIQSIM cannot establish a connection to the SMIQ via RS232. In this case, the baud rate of the SMIQ can be changed manually via UTILITIES ⇒ SYSTEM ⇒ RS232 ⇒ BAUD RATE.

Transmission
With the **After transmission: Automat. select Waveform. After selection: Automat. set ARB state to ON** option selected, an IQ waveform file transmitted to the SMIQ is automatically loaded into the output buffer and signal output is started. Thus the new signal can be used immediately after the transmission without the need to call the SMIQ ARB Remote panel.

The panel is quit with the **OK** button. When the **Cancel** button is pressed all settings made are discarded.

5.26.6 Several Controllers on the Bus

WinIQSIM must control the SMIQ when the SMIQ Transmission or the ARB Remote Control panel is to be set up on the screen. The controller on which WinIQSIM is installed must therefore be the controller on the IEC bus. If another controller is connected to the shared bus which is to control e.g. the SMIQ, there will be problems if the two controlling devices want to be the controller on the bus at the same time which is not allowed by the bus specification. In the case of bus conflicts, the error message ‘Communication to SMIQ (GPIB) failed’ or 'Can't open SMIQ session. No communication to SMIQ possible' will appear when the remote-control menus are called up.

WinIQSIM abandons the control on the IEC bus when you quit the Transmission or ARB Remote Control menus again.

The device controlling the SMIQ as controller must also be able to abandon the control. Usually, this case will not be considered in the (system) control programs. It is not at all sure whether upon completion of these programs the bus interface will be set to passive state.

6 BER Measurement with Option AMIQ-B1

6.1 Overview

With the aid of option AMIQ-B1 the bit error rate produced by a DUT or as a result of condition simulation can be measured (BERT = bit error rate test).

The description given below is valid from AMIQ firmware version 3.0. As compared with previous versions, the option of integrating measurements in BER tests has changed also for the use of restart pulses. The current AMIQ software version is displayed in the information line in the AMIQ Remote Control and BERT panel. For information on updating the AMIQ software please refer to the AMIQ manual.

Since AMIQ does not have any control elements, the BER measurement is performed either via the WinIQSIM program or remote-controlled from a Vector Signal Generator SMIQ. The following section **Control Elements and Display of BER Measurement** gives an overview of the setting capabilities. For test methods and basic information refer to the AMIQ manual and to the sections further down in this manual.

If the input data for the DUT are generated by AMIQ - or by a combination of AMIQ and SMIQ - a PRBS can in the simplest case be selected as the source for waveform generation by AMIQ with WinIQSIM. The settings required for this generation are described in the section **Continuous PRBS for BER Measurement**. This section also deals with the generation of a marker to be used as a restart signal for the BERT when the PRBS is not continuously applied. This is the case when the quotient of the PRBS length to the modulation level or an integral multiple thereof cannot be set as the trace length. The PRBS does not run smoothly and cannot therefore be used for a continuous measurement. If a clock signal has to be generated in addition, another marker can be automatically generated by WinIQSIM. The case of a continuous PRBS is also described in this section.

When a TDMA (time division multiple access) signal has to be used according to the standard, the signal is generated with the data editor of WinIQSIM. The data signal is not continuous, ie the BER measurement must be informed by a data enable signal when valid data are present and when the PRBS is interrupted by synchronization sequences, preambles, power ramps, etc. Like the clock and restart signals, the data enable signal can be generated by means of a marker and is required when the transfer clock for the PRBS data is not generated by the DUT. The special settings required in this case are described in the section **Data Editor for BER Measurement** further down. This section also describes the automatic generation of the clock and restart signals by WinIQSIM when the data editor is used.

Since there is always a delay between the input and output of the DUT, which is at first not known, the clock signals have to be delayed. The measurement of this delay and the required settings are described in the section Marker Shift for BER Measurement.

BER measurements can also be performed with data from a source other than AMIQ. In such case, however, at least the clock signal must be generated externally. If the data are not applied continuously, the clock must be interrupted as well or an enable signal provided for the clock. Moreover, the data must be derived from a PRBS (pseudo random binary sequence) source which has to run continuously in a defined sequence without any interruption. If the latter condition is not met, an external restart signal is required as well.

Please consult the AMIQ manual for information on the following:

- Connector
- Signal path and waveform
- Test method
- PRBS polynomials
- Measurement result, accuracy, measurement time
- Installation of option

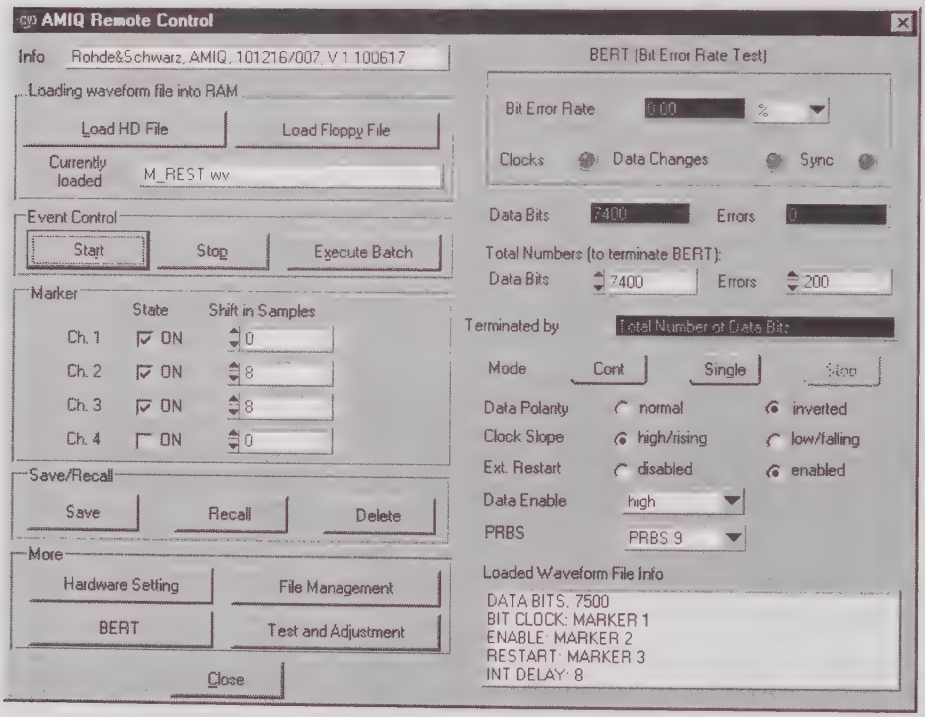
6.2 Control Elements and Display of BER Measurement

This section gives an overview of possible settings. For test methods and basic information refer to the AMIQ manual and to the sections further down in this manual.

The control elements for the BER measurement are accessible via the AMIQ menu in the main panel. When an AMIQ is connected (see section 5.27.4, AMIQ Remote Control Panel), the AMIQ Remote Control panel is activated by selecting Remote Control and BERT... under AMIQ in the main panel. If an AMIQ-B1 option is identified in the AMIQ, the BERT button is active (not grey).

If option AMIQ-B1 is not factory-fitted, it is to be installed as described in the AMIQ manual. The option is enabled by means of a remote control command. To enter this command, click on the "Test and Adjustment" button to open the "Send Command to AMIQ" menu window. Enter the enable code in the "Command" line and transfer it to AMIQ with the "Send" button.

When the BERT button is pressed, the display and control elements required for the BER measurement are displayed. They are described in the following.



Info: Rohde&Schwarz, AMIQ, 101216/007, V 1 100617

Currently loaded: M_REST wv

	State	Shift in Samples
Ch. 1	☑ ON	0
Ch. 2	☑ ON	8
Ch. 3	☑ ON	8
Ch. 4	☐ ON	0

Bit Error Rate: 0.00 %

Data Bits: 7400 Errors: 0

Total Numbers (to terminate BERT):

Data Bits: 7400 Errors: 200

Terminated by: Total Number of Data Bits

Data Polarity: ○ normal ● inverted

Clock Slope: ● high/rising ○ low/falling

Ext. Restart: ○ disabled ● enabled

Data Enable: high

PRBS: PRBS 9

```
DATA BITS. 7500
BIT CLOCK: MARKER 1
ENABLE· MARKER 2
RESTART· MARKER 3
INT DELAY· 8
```

Fig. 6-1 AMIQ Remote panel with BERT extension

Bit Error Rate: In this field the measured BER is indicated, ie the quotient of accumulated faulty bits to total bits. During the first measurement started with the Single or Cont mode button, also intermediate results are displayed in this field. If a continuous measurement is performed (Cont mode) only final results are displayed for all subsequent measurements (see Mode). In the field at the right of the result display, percent (%), parts per million (ppm) or --- for no unit can be selected.

Clocks, Data Changes and Sync: The three lamps below the BER field signal the states of clock line, data line and synchronization. When a change of the clock signal is detected, the Clocks lamp lights green. The same applies to the Data Changes lamp, when no data change is identified, the Data Changes lamp is grey. Another reason for this may be that 'always' is not selected for Data Enable and the data are not activated by the enable signal. Sync indicates a successful attempt of PRBS synchronization. Only when all 3 lamps are green are the results valid and is the display active (not grey).

Data Bits: The number of data bits attained since the start of the first measurement or of each subsequent measurement is displayed. Only the clocks activated with Data Enable are counted.

Errors: The number of erroneous data bits since the start of the first measurement or of a subsequent measurement is indicated. If a difference is found between the expected data value and the currently present data bit, the error count is incremented.

Total Number (to terminate BERT): The first measurement or any subsequent measurement (in the Cont mode) is terminated when a certain number of data bits or errors is attained. This limit can be entered here by the user.

Entering a maximum number of data bits is useful, for example, if the BER is to be measured during a defined period of time. The larger the number of data bits, the longer the time until a new BER is indicated in the Bit Error Rate field. If the BER is very low, for example 1 ppm, a BER indication different from 0 cannot be expected until after 1 million data bits. Statistically, such BER indication may not be obtained until after a much higher number of data bits.

Terminated by: In this field the event that terminates the measurement is indicated.
A single measurement (Single mode) or any subsequent measurement (Cont mode) is stopped when one of the following conditions occurs:

- The preset number of data bits is reached.
- The preset number of errors is reached.
- The measurement was stopped by the user (Stop button).

Mode: Here the measurement mode can be selected.

- **Cont** starts a quasi-continuous measurement. A new measurement is triggered after the first one (see single measurement) and any subsequent measurement - which are terminated as described above. The data bit and error counters are reset to 0 for each new measurement. At the end of each measurement, the BER accumulated from the start until the end of the new measurement is displayed in the Bit Error Rate field.
- **Single** triggers a single measurement. During this measurement also intermediate results are displayed in the Bit Error Rate field.
- **Stop** terminates the current measurement.

Data Polarity: The signal at the data input can be selected as **Normal** or **Inverted.**

Clock Slope: The rising (**High/rising**) or falling (**Low/falling**) slope can be used at the clock input. If a marker generated by WinIQSIM is used as a clock signal, High/rising should be selected.

Ext. Restart: The signal at the restart input is used (**Enabled**) or not used (**Disabled**). The restart signal re-synchronizes the PRBS for data comparison. All partial results are continuously summed up, however.

Data Enable: When the data signal is not continuous (with each clock), the evaluation can be interrupted by setting a Data Enable signal.

- with **high,** data are only evaluated when high level is present at the input.
- with **low,** data are only evaluated when low level is present at the input.
- **always** deactivates the data enable signal. All data are used for the BER measurement.

High should be selected when a marker automatically generated by WinIQSIM is used as a data enable signal.

PRBS: Different types of random bit sequences can be set. The type present at the input of the DUT must be selected. If the data of a trace loaded in the AMIQ come from a PRBS source, the type of the applied PRBS is automatically set.

Loaded Waveform File BERT Info: Main settings made by the user for the generation of the AMIQ trace by WinIQSIM are stored with the trace as part of the *.wv file. The settings relevant for the BER measurement are displayed in this window. The data are also displayed when they are directly transferred from WinIQSIM to the RAM of AMIQ.

- **DATA BITS** indicates the number of PRBS data bits contained in the AMIQ waveform. This value can be entered as "Data Bits" under "Total Number (to terminate BERT)" if a single measurement (without restart signal) is to be carried out. A safety margin of about 40 bits should be left for synchronization (see AMIQ manual).
- **BIT CLOCK**, **ENABLE** and **RESTART** indicate the marker channels used for these signals, ie outputs that have to be connected to the inputs of BERT. ENABLE is only available when the trace data were generated with the data editor.

6.3 Continuous PRBS for BER Measurement

The simplest case is the measurement with a continuous data sequence where the data flow is not interrupted like in time-multiplex systems. The data signal is **not** generated with the data editor but **PRBS** is selected as a data source in the **Data Source** panel.

The type of the PRBS (pseudo random binary sequence) determines the Sequence Length to be set in the Modulation Settings panel:

Type	**PRBS Length (2^n-1)**
PRBS 9	511
PRBS 11	2047
PRBS 15	32767
PRBS 16	65535
PRBS 20	1048575
PRBS 21	2097151
PRBS 23	8388607

If the PRBS length or an integer multiple thereof is set as **Sequence Length,** the PRBS runs "smoothly" and only then is a continuous measurement possible, ie without the need for a restart signal (input via BER connector). The PRBS should be continued without a break at the wraparound point in the AMIQ memory.

The Cont mode is very useful if the cumulated result is of no interest but variations are to be observed. The measurement time is controlled by the entered number of data bits or errors.

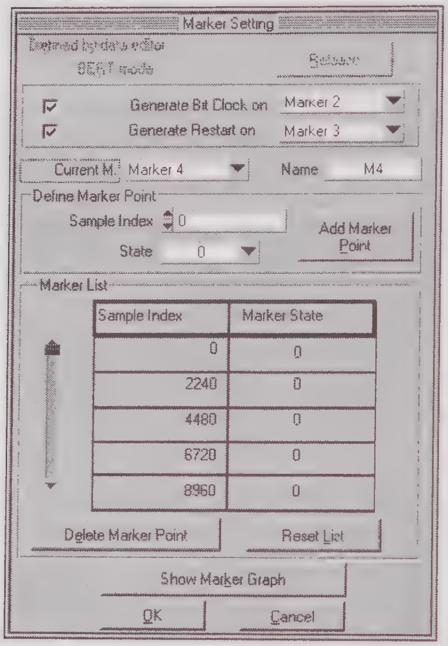
If the PRBS length or an integer multiple thereof cannot be set and if no restart signal is available, single measurements can be performed. A single measurement must be stopped after the last value before wraparound is made to the start value of the AMIQ waveform.

The bits to be measured can be entered in the **Data Bits** field under Total Number (to terminate BERT) in the BERT panel. If the number is equal to the sequence length * modulation level or about 200 bits shorter to allow for data bit synchronization and delays, the measurement is stopped before the wraparound to the start value of the AMIQ trace. The measurement must be restarted synchronously. To do so stop the trace output with the Stop key in the Event Control window of the AMIQ Remote Control panel. Restart the measurement with the Single button in the BERT panel. The measurement is restarted only when a clock is present, ie after the trace has been started with the Start button in the Event Control window.

To be able to set a correct number of bits, the number of the employed data bits (sequence length * modulation level) is displayed as DATA BITS in the Loaded Waveform File Info box.

The best method is the use of the **Restart** signal. In this case Ext. Restart in the BERT panel is Enabled. With the aid of a marker a restart signal can be generated which marks the first value in the AMIQ trace. It starts the next measurement after the wraparound of the PRBS.

Continuous display can be started with the "Cont" button under "Mode" in the BERT panel. The data bit and error counters are reset to 0 for each new measurement; the Bit Error Rate field however indicates the accumulated BER.



☑ Generate Bit Clock on: Marker 2
☑ Generate Restart on: Marker 3
Current M.: Marker 4
Name: M4

Define Marker Point
Sample Index: 0
State: 0

Marker List

Sample Index	Marker State
0	0
2240	0
4480	0
6720	0
8960	0

Fig. 6-2 Marker Setting panel

The marker used as a restart signal is generated by selecting **Generate Restart** in the Marker Settings panel accessible via the AMIQ menu and transferred via a cable connected between the marker output and the BERT input (see AMIQ manual).

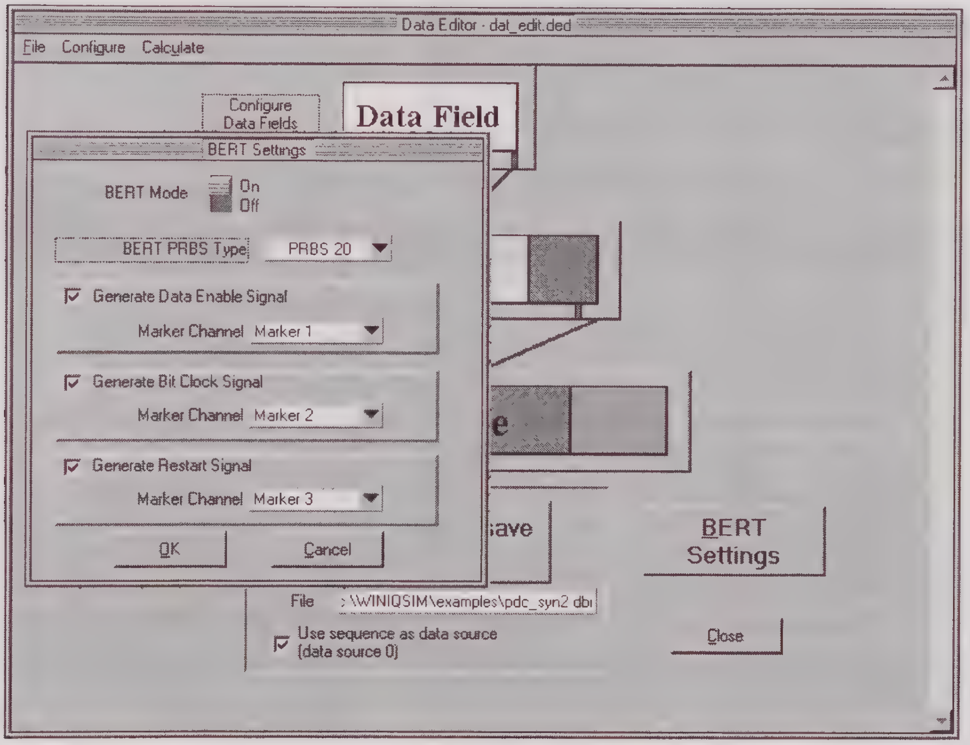
If the marker should be used to generate a bit clock, **Generate Bit Clock** must be set in the Marker Settings Panel accessible in the AMIQ menu, and the respective connectors linked by means of a cable.

The two functions are disabled when the markers are already assigned in the BERT part of data editor. With the markers used as markers by the data editor, 'Defined by data editor' is displayed in red. If they are used by the data editor (!) for the BERT mode, BERT mode is displayed as a warning at the top of the Marker Setting panel. In both cases the assignment can be disabled with the **Release** button. Note: 1 or 2 markers of 4 are assigned. One of the four marker lists can be displayed in the Marker List window below. The marker list is not active, however, when the same marker (same number) is used for Generate Bit Clock and Generate Restart. The non-active list can be edited but is not considered in the AMIQ trace.

6.4 Data Editor for BER Measurement

When a TDMA (time division multiple access) signal has to be used according to the standard, the signal is generated with the aid of the data editor of WinIQSIM. This data signal is not continuous, ie the BER measurement must be informed by a **data enable signal** when valid data are present and when the PRBS is interrupted by synchronization sequences, preambles, power ramps, etc. Like the clock and restart signals, the data enable signal can be generated by means of a marker and is required when the DUT does not generate a data clock (which should only be present when PRBS data are available).

Therefore, if the data sequence is created with the data editor, a panel can be opened with the BERT Settings button, where the marker can be set.



BERT Mode On / Off

BERT PRBS Type PRBS 20

☑ Generate Data Enable Signal
Marker Channel Marker 1

☑ Generate Bit Clock Signal
Marker Channel Marker 2

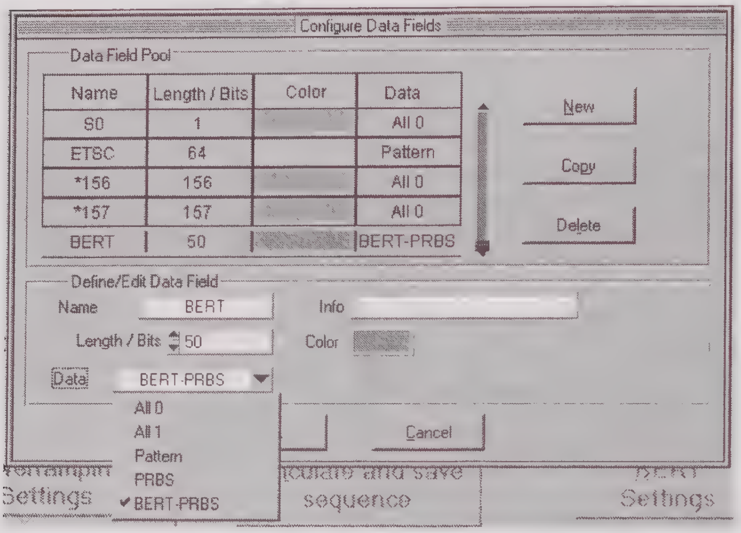
☑ Generate Restart Signal
Marker Channel Marker 3

File :\WINIQSIM\examples\pdc_syn2 dbı

☑ Use sequence as data source (data source 0)

Fig. 6-3 Main panel of data editor with BERT Settings extension

Data of the (BERT) PRBS must be activated with the **data enable** signal. Since the marker generated for this purpose is closely related to the PRBS, a separate **BERT-PRBS** data source is available for the data fields (in the Configure Data Fields panel accessible in the Data menu). This source has to used when the data enable signal is generated on a marker and used exclusively for the data stream to be measured.



Name	Length / Bits	Color	Data
S0	1	▨	All 0
ETSC	64		Pattern
*156	156	▨	All 0
*157	157	▨	All 0
BERT	50	▨	BERT-PRBS

Name BERT

Info

Length / Bits 50

Color ▨

Data BERT-PRBS

Fig. 6-4 Configure Data Fields panel of data editor with BERT-PRBS chosen

The frame created with the data editor and therefore the AMIQ trace does not normally contain a complete PRBS. The **Restart signal** is therefore required and a marker has to be generated.

The marker used as a restart signal is generated by selecting **Generate Restart Signal** in the BERT Settings panel and must be connected from the marker output to the BERT input via a cable (see AMIQ manual). The Ext. Restart mode is enabled in the BERT panel of AMIQ.

If a marker should be used for bit clock generation, **Generate Bit Clock Signal** must be selected in the BERT Settings panel, and the respective connectors linked by means of a cable.

The markers for the BER measurement have to be matched to the number of AMIQ trace samples. For instance, with oversampling 8 and modulation level 2 selected, a data bit takes up 4 samples of the AMIQ trace. In this case a bit clock comprises 2 samples of low and 2 samples of high level. Because of this relationship, settings should be made in the following order:

- ➢ Make settings in the Modulation Settings panel (particularly modulation and oversampling).
- ➢ Call the data editor in the Data Source panel and configure the desired sequence (or load a configuration file with File Open)
- ➢ Open the BERT Settings panel and switch the BERT Mode On.
- ➢ Set the marker generation.
- ➢ Specify a file for 'Calculate and save sequence', select 'Use sequence as data source' and press the button. The data and marker lists are thus generated.
- ➢ By selecting 'Use sequence as data source', Data File is automatically selected in the Data Source panel and the data name is transferred. Note: If a file is selected without 'Calculate and save sequence', automatically generated markers are not available.
- ➢ The value specified for Frame Length / modulation level in the Configure Frame panel of the data editor is now displayed as Sequence Length in the Modulation Settings panel.
- ➢ Start trace generation and transmission by selecting Transmission... in the AMIQ menu.
- ➢ Open the BERT panel by selecting Remote Control and BERT in the AMIQ menu and pressing the BERT button. The information on the set markers should now be displayed in the Loaded Waveform File Info box.
- ➢ The PRBS type should be set automatically.
- ➢ Set the marker shift (see Marker Shift for BER Measurement).

6.5 Marker Shift for BER Measurement

The output signal to be measured is normally delayed in the DUT by a constant time as against the input signal. Since the markers are not routed through the DUT but applied directly from the AMIQ output to the BERT input, the marker signals must also be delayed since they are generated by WinIQSIM synchronously to the data signal. The marker signals in AMIQ can be subsequently shifted by a specific number of samples. This shift can be set in the Marker window of the AMIQ Remote Control and BERT panel.

The markers (channels) in use can be seen in the Loaded Waveform File BERT Info box. The marker must first be activated with ON.

If the DUT generates its own clock, the bit clock and data enable signals generated in the AMIQ with the markers are not needed. If a continuous PRBS is used, the restart signal is not required either. In all other cases the markers must be shifted with the aid of an oscilloscope as described below:

The structure of the clock signal is explained by taking the bit clock marker signal as an example: For instance, with oversampling 8 and modulation level 2, a data bit takes up 4 samples of the AMIQ trace. In this case a bit clock comprises 2 samples of low and 2 samples of high level.

If the quotient of oversampling / modulation level is an even number, the **bit clock** marker signal for the high/low transition is exactly in the center of the data bit, in all other cases it is asymmetrical by one sample. Consequently, the quotient of oversampling / modulation level must be at least 2. Otherwise the warning 'Marker Info...' is output upon signal generation and transmission (AMIQ: Transmission...). The higher the oversampling / modulation quotient, the more exactly can the bit clock be centered in the data signal. A shift is therefore useful in the range between 0 and the oversampling / modulation quotient less 1 and is entered in the Shift in Samples field.

The data enable signal must be accurately set to the sum of all delays caused by the WinIQSIM filters, AMIQ filter, SMIQ filter and the DUT. The signal delay caused by the filters of WinIQSIM in the calculation is specified in samples under INT DELAY in the File Info box. If the total delay cannot be obtained by calculation, it should be determined with the aid of an oscilloscope (possibly through the use of only 0 or 1 as data). The data enable signal in the AMIQ can be shifted by trial and error until it is exactly positioned on the data range.

The restart signal must be shifted to prevent the measurement being restart a few bits to early. However, if the total delay is already known for the data enable signal, this value can also be entered for the shift in samples.

7 Multi Carrier

In addition to single-carrier signals, multicarrier signals with all characteristic parameters such as number of carriers (up to 512), carrier spacing, modulation and power can be simulated. In this way, composite signals consisting of modulated and unmodulated carriers can be configured or useful signals with superimposed impairments be generated.

The multicarrier system is described in this chapter, but only regarding the differences from the single carrier system that has already been described in chapter 5. In the block diagram of the multicarrier system the Modulation block is replaced by the Carrier Settings block (see chapter 7.3). The Data Source block has been enhanced compared to the single carrier system (see chapter 7.2).

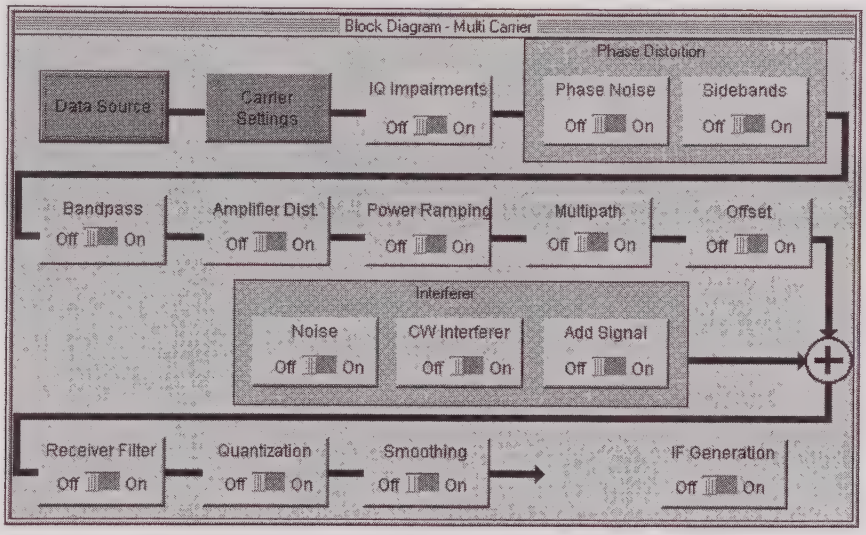


Fig. 7-1 Multicarrier block diagram

7.1 Status Line

The main parameters of a transmission system are displayed in a status line below the toolbar of the main panel. So the set parameters can be seen at a glance.

The status line contains symbols for the different parameters; below the symbols the current parameter value is indicated. The illustration below shows the status line of the multicarrier system. The parameters pertaining to the symbols are also shown in the diagram.

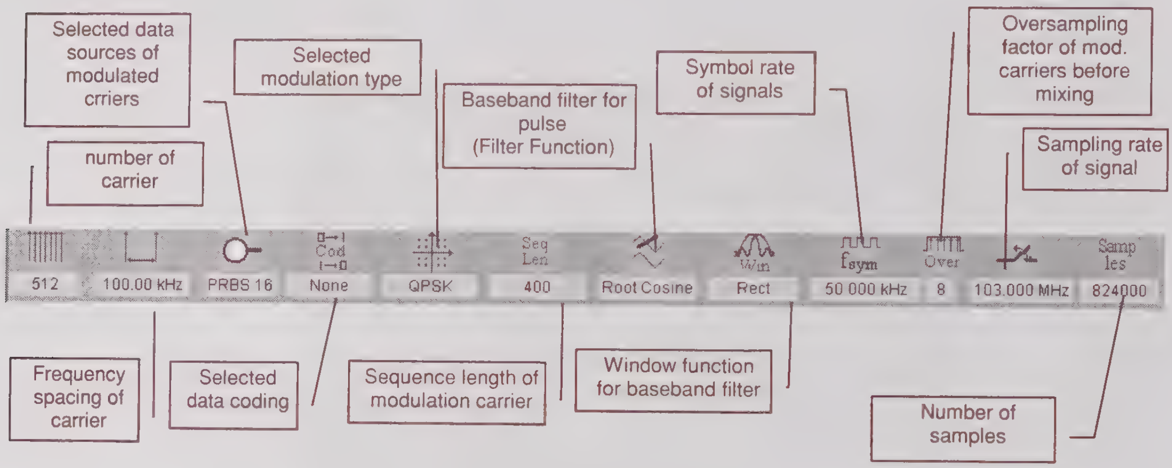
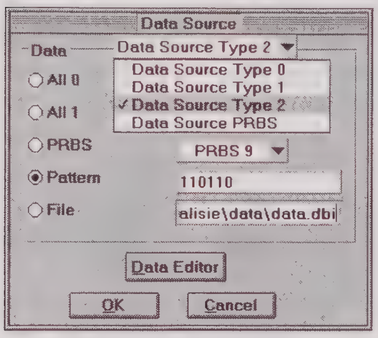

Selected data sources of modulated crriers
Selected modulation type
Baseband filter for pulse (Filter Function)
Symbol rate of signals
Oversampling factor of mod. carriers before mixing
number of carrier
Sampling rate of signal
Cod
Seq Len
Win
fsym
Over
Samp les
512
100.00 kHz
PRBS 16
None
QPSK
400
Root Cosine
Rect
50 000 kHz
8
103.000 MHz
824000
Frequency spacing of carrier
Selected data coding
Sequence length of modulation carrier
Window function for baseband filter
Number of samples

Fig. 7-2 Multicarrier status line

7.2 Data Source (Multi Carrier)

The Data Source block of the multicarrier transmission system is different from that described in section 5.6 for the single-carrier system.

Four different types of data sources can be selected for multicarrier transmission systems, which are assigned to the individual carriers in a next step. **Data Source Type 0, Data Source Type 1, Data Source Type 2** and the special type **Data Source PRBS** can be selected. The four data sources are configured in the multicarrier Data Source panel in the same way as the one for the single-carrier system. The individual data sources and their parameters can be selected in a field at the top of the Data Source panel.



Data Source Type 2

PRBS 9

● Pattern 110110

○ File alisie\data\data.dbi

Fig. 7-3 Data Source panel of multicarrier system

The selection items and control elements for a multicarrier data source have the same functions and meaning as those described for the single-carrier system. For this reason only a brief summary will be given here.

Four different binary data sources can be selected successively in the Data Source panel for I/Q signal generation. Five different types of data sources are available: **All 0**, **All 1**, **PRBS**, **Pattern** and **File**. The desired data source can be selected by a mouse-click on the respective button. A brief description of the data source types is given below:

All 0: Data source All 0 sends a sequence of binary 0 symbols.

All 1: Data source All 1 sends a sequence of binary 1 symbols.

PRBS: This data source can generate different pseudo-random binary sequences.
The types **PRBS 7**, **PRBS 9**, **PRBS 11**, **PRBS 15**, **PRBS 16**, **PRBS 20**, **PRBS 21** and **PRBS 23** can be selected in the field at the right of the PRBS button.
PRBS sources are defined in the CCITT V.52 or Rec. 0.151 standard.

Pattern: A bit pattern can also be used as a data source. For instance, if a bit pattern with the length four {b} = {1, 1, 0, 1} is defined, a 10-bit data sequence {d} = {1, 1, 0, 1, 1, 1, 0, 1, 1, 1} is obtained. The selected bit pattern is repeated until the desired data length is attained. If the bit pattern is longer than the required data sequence, only the first bits of the pattern are used.
The currently set bit pattern is indicated at the right of the Pattern button.

File: The data source may also be a data file. The selected file is indicated in the field at the right of the File selection box. A click with the left mouse key on this field opens the File Select (popup) window where the file can be selected. The extension used for these files is **.dbi** (for data bits). Other extensions are not permissible.

One of the five data types can be selected for Data Source types 0, 1, 2. The PRBS data source is a special type which only generates PRBS data. Therefore, with **Data Source PRBS** selected, only the

PRBS selection field is active. All other selection fields are disabled (grey). Three individually configured data sources can thus be selected for carriers of particular interest. The PRBS data source should be used for all the carriers which make up the impairment scenario. Selecting the option **Different start values for PRBS** in the Carrier Settings panel reduces the correlation between the carriers using this source.

The data editor can also be called in the Data Source panel. It is a convenient tool for generating data files and described in the section 5.7.

The Data Source panel can be quit with the **OK** and **Cancel** buttons (see section 5.6).

7.3 Carrier Settings Panel

The main parameters of a multicarrier signal are defined in the Carrier Settings panel. General parameters like carrier number and carrier spacing and carrier-specific parameters like power and modulation can be set in this panel. Before the panel and its control elements are described, the multicarrier system model used by WinIQSIM will be briefly outlined.

Model

A multicarrier scenario with up to 512 carriers can be defined by WinIQSIM. An equidistant carrier pattern is assumed in this case. Each carrier may be modulated or unmodulated. Same as in the single-carrier mode, a modulation and an impairment scenario can be defined. This single-carrier scenario is then used for all carriers to be modulated (Modulation ON). This means that all the carriers are modulated in the same way and the same impairments are added to them. The multicarrier signal is calculated so that a signal is built-up symmetrically around the RF carrier. If an odd number of carriers is used, the central carrier is exactly on the RF carrier frequency, with an even number of carriers, the two central carriers are positioned symmetrically at the same distance at the left and right of the RF carrier.

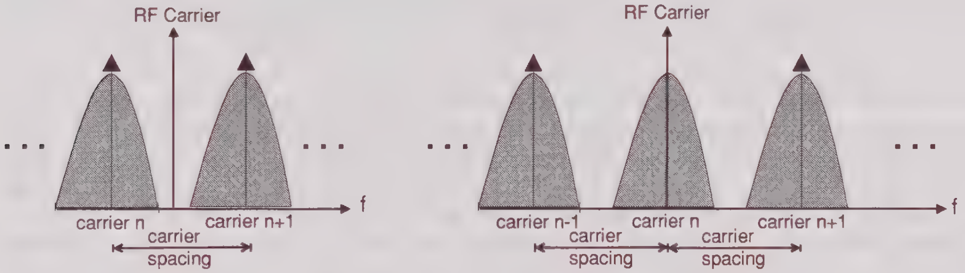
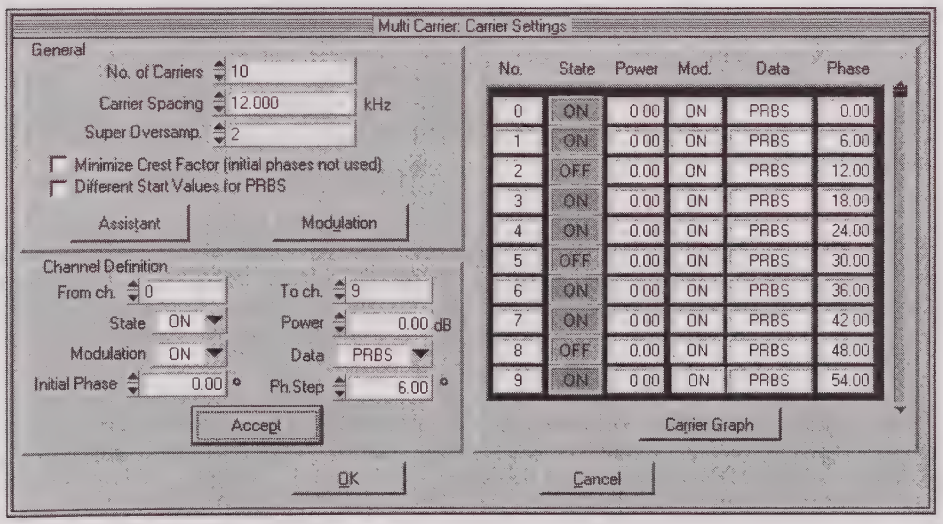


Fig. 7-4 Position of carriers (even and odd number) relative to the RF carrier

The block diagram of the multicarrier system differs from that of the single carrier system by two blocks only. In the multicarrier system, several data sources can be defined in the Data Source block and the Carrier Settings block is replaced by the Modulation Settings block. Same as in the single-carrier system, all modulation parameters and impairment components can be defined in the setting panels which correspond to the blocks in the diagram.



No. of Carriers 10
Carrier Spacing 12.000 kHz
Super Oversamp. 2
☐ Minimize Crest Factor (initial phases not used)
☐ Different Start Values for PRBS

From ch. 0
To ch. 9
State ON
Power 0.00 dB
Modulation ON
Data PRBS
Initial Phase 0.00 °
Ph.Step 6.00 °

No.	State	Power	Mod.	Data	Phase
0	ON	0.00	ON	PRBS	0.00
1	ON	0.00	ON	PRBS	6.00
2	OFF	0.00	ON	PRBS	12.00
3	ON	0.00	ON	PRBS	18.00
4	ON	0.00	ON	PRBS	24.00
5	OFF	0.00	ON	PRBS	30.00
6	ON	0.00	ON	PRBS	36.00
7	ON	0.00	ON	PRBS	42.00
8	OFF	0.00	ON	PRBS	48.00
9	ON	0.00	ON	PRBS	54.00

Fig. 7-5 Carrier Settings panel

General
In the General window all general carrier settings can be made. This includes the number of carriers, the frequency spacing and the modulation.

Number of Carriers: In this field a number of carriers between 1 and 512 can be selected for the multicarrier system. The carriers are consecutively numbered starting with 0. The defined carriers are entered in the scrollable table in the bottom window of the panel. As the number of carriers is increased, a corresponding number of preset entries (State OFF, Power 0 dB, Modulation OFF, Data 0) is added to the table. If the number of carriers is reduced, the unused carriers at the end of the table are cleared.

Carrier Spacing: The frequency spacing of two adjacent carriers can be set in this field between 0.001 kHz to 1000 kHz.

Minimize Crest Factor (initial Phase not used)): With this option an internal algorithm is switched on for improving the crest factor. The start phase of the individual carriers is set so that the crest factor is reduced. If the start phases of the individual carriers are identical, high signal peaks may occur compared to the average signal value (demodulated value). These periodically recurring peaks occur when single carriers with the same start phase are superimposed. With the Minimize Crest Factor option activated, the start phases displayed in the channel table are not used, the respective column in the table is dimmed.

Different start values for PRBS: With this option, different start values can be set for the shift registers used for generating PRBS data for all modulated carriers using the PRBS data source. This reduces the correlation between the I/Q signals and the individual carriers. Switching on this option should be carefully thought over, however. With this option selected, all I/Q signals of the respective carriers have to be individually calculated. The result is that the usual strategies to reduce the volume of calculations cannot be employed. Depending on the number of modulated carriers, very elaborate and time-consuming calculations may have to be performed in this case.

Modulation: The Modulation Settings panel is called with the Modulation button. In this panel, which has already been described in section 5.8, all modulation parameters like modulation type, symbol rate, baseband filter and oversampling can be set.

When configuring the general parameters of the multicarrier system, make sure that the current sampling rate is not higher than the maximum clock rate of 100 MHz of AMIQ as otherwise signal calculation will not take place. The current sampling rate is always indicated in the status line of the main panel. The sampling rate increases with the number of carriers, carrier spacing and bandwidth of the set modulation as described by

$$f_{sample} = (Number\_of\_Carrier - 1) \cdot Carrier\_Spacing + Oversampling \cdot Symbol\_rate$$

The sampling rate is therefore obtained from the total bandwidth of the carrier constellation and the modulation bandwidth of the carriers.

Channel Definition
Carrier-specific parameters like power, use of modulation and data source are set in this window. The carrier range for which the parameters set in the State, Power, Modulation and Data fields are valid is defined in the **From channel** and **To channel** fields. These settings are transferred to the carrier table with the **Accept** button to become effective. The possibility to configure whole ranges together considerably simplifies operation.

From/To channel: Here the range for which the subsequent parameters apply is defined. The range is always 0 to (number of carriers - 1). An ascending range (eg from 3 to 17) or a descending range (from 17 to 3) can be specified.

State: A decision can be made in this field whether the carriers in the selected range should be visible in the signal (ON) or not (OFF). By switching off some of the carriers, non-equidistant multicarrier constellations can be obtained.

Power: In this field, a value can be assigned to each carrier to amplify the carrier power in comparison to the others. A value in the range -80 dB to 0 dB can be set. This parameter is only effective when the State is set to ON.

Modulation: In this field it is decided whether the carrier is modulated (ON) or not (OFF). In the OFF state a pure CW carrier is displayed. With ON selected, the whole single-carrier scenario set in the block diagram is calculated for this carrier. This parameter is only effective when State is set to ON.

Data: One of the four data sources (Data 0, Data 1, Data 2, PRBS) configured in the Data Source panel can be assigned to any carrier for which State ON has been selected and which is modulated. If the same data source is used for all carriers, the respective data type is displayed in the status line of the main panel. If different data sources are used, **Various** is displayed in the status line. If all carriers are unmodulated or switched off, **Not used** is displayed.

Initial Phase: In this field, the start phase of the channel can be freely selected in the range from 0° to 360°. The **Phase Step parameter** is used for easy configuration of several channels with equidistant start phase. Thus it is possible, for instance, to generate five channels which are to have the start phases 10°, 35°, 60°, 85° and 110° by setting Channel 0, Stop Channel 4, Initial Phase 10° and Phase Step 25° and subsequently pressing the Accept button. You may use the start phase parameter to generate your own optimized scenarios for minimizing the crest factor . If the Minimize Crest Factor option is active, the set start phases are not effective and are dimmed in the table.

A carrier can be selected with the aid of the mouse in the table in the lower window of the panel. The selected carrier is marked by an orange frame and transferred to the Channel Definition window where it can be modified.

Carrier Graph: Pressing the Carrier Graph button opens an action panel where the defined carrier constellation is qualitatively displayed in a scrollable graph on a carrier axis.

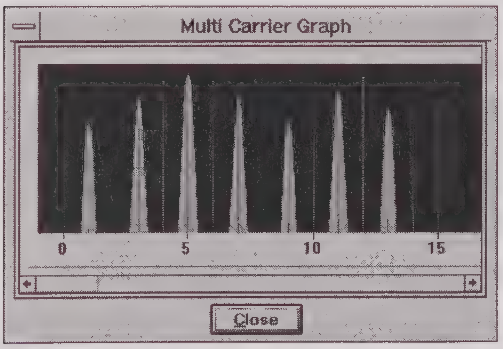


Fig. 7-6 Multicarrier Graph panel

Unmodulated carriers are displayed as a red spectral line. A symbolic modulation spectrum is displayed in green around the carrier frequency for modulated carriers. The height of the spectral lines or of the modulation spectrum depends on the set carrier power. The Carrier Graph panel can be quit with the **Close** button.

The Carrier Settings panel can be quit with the **OK** and **Cancel** buttons. With Cancel selected, all modifications made to the settings are discarded.

7.3.1 Assistant Function for Determining the Carrier Spacing

If a multicarrier I/Q signal is to be generated, certain conditions of the modulated baseband I/Q signal and the carrier spacing must be fulfilled to generate a precision signal. In particular at the wrap around point, ie the point at which the AMIQ output signal changes from the end to the start of the signal, there may otherwise be amplitude differences causing unwanted spikes in the spectrum.

The time period of the baseband I/Q signal to be modulated upon the carriers must be equivalent to an integer multiple of the oscillation period with the minimum (ie closest to the RF carrier) carrier frequency. With an even number of carriers the minimum frequency spacing from the RF carrier is half the carrier spacing. The following relationship must therefore apply:

$t_{IQ-Signal} = n \cdot \frac{2}{f_{Spacing}} \quad n \in /N^{+}$ with the time period of the I/Q signal being obtained as the ratio of sequence length and symbol rate.

The following illustration shows a multicarrier signal with a carrier spacing which does not meet the above condition. The displayed wrap around point shows distinct spikes both of the I and the Q amplitude.

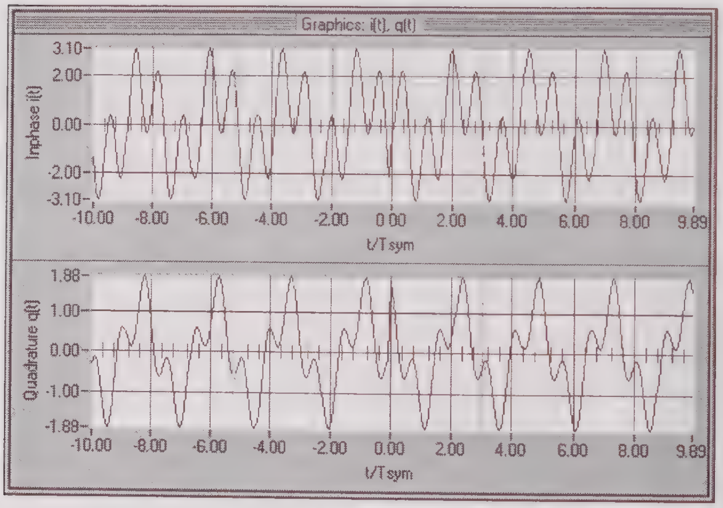
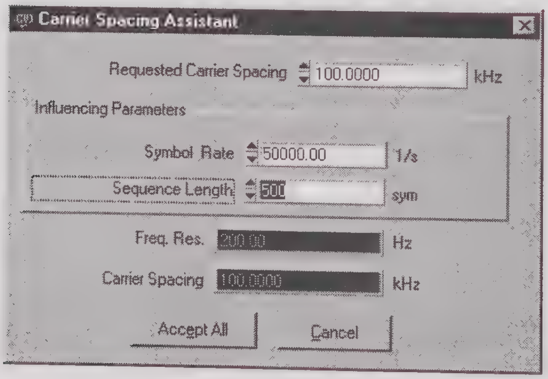


Fig. 7-7 Wrap around of a multicarrier signal with carrier spacing set without assistant function

In order to solve this wrap around problem, the assistant function has been integrated which can be activated with the **Assistant** button in the Offset panel. After actuating this button, the following modal dialog window is opened.


Carrier Spacing Assistant

Requested Carrier Spacing 100.0000 kHz

Influencing Parameters

Symbol Rate 50000.00 1/s

Sequence Length 500 sym

Freq. Res. 200.00 Hz

Carrier Spacing 100.0000 kHz

Fig. 7-8 Carrier spacing assistant function

The desired carrier spacing can be entered in the **Requested Carrier Spacing** field. The modulation parameters influencing the setting of the spacing are entered in the **Influencing Parameters** field. The influencing parameters can be varied in this field to determine the carrier spacing that does not cause any wrap around problems (**Carrier Spacing** field). The resolution for varying the carrier spacing without any problems is stated in the **Frequency Resolution** field. WinIQSIM automatically selects a carrier spacing that causes no problems.
The frequency resolution is defined as

$f_{resol} = \dfrac{2 \cdot f_{symbol}}{Sequenzlänge}$, ie the ratio of twice the symbol rate of I/Q signal and the sequence length in symbols. The longer the I/Q sequence, the more accurate is the setting of the carrier spacing without wrap around problems.

If the panel is closed with the **Accept All** button, all set parameters are accepted, whereas with the **Cancel** button all settings are discarded.

The result of setting the carrier spacing with the assistant function is shown in the figure below.

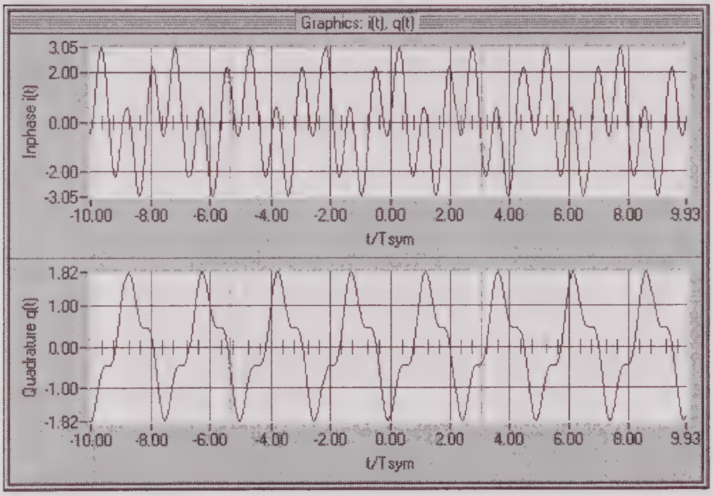


Fig. 7-9 Wrap around of a multicarrier signal with carrier spacing set with assistant function

8 3GPP W-CDMA

WinIQSIM can generate 3GPP W-CDMA signals. Section 8.1 gives an overview of this mobile radio transmission method. Section 8.2 describes the associated control functions. Section 8.3 provides in-depth information about the generation of 3GPP W-CDMA signals.

8.1 Description of Mobile Radio Transmission Method 3GPP W-CDMA

W-CDMA (wideband CDMA) designates a group of mobile radio transmission methods which differ in numerous details. WinIQSIM provides a version developed by the 3 GPP standard organisation ("3rd Generation Partnership Project").
This version can be regarded as a synthesis of the IMT-2000 as proposed by

- Association of Radio Industries and Businesses (ARIB)
- The European Telecommunications Standards Institute (ETSI)

and is thus also the successor of versions NTT DoCoMo 1.0, ARIB 1.0 and W_CDMA to 3GPP Version 2.0.0, 2.1.0, 3.0.0 and 3.2.0 implemented in former WinIQSIM versions.

The current version (WinIQSIM Version 3.40 or higher) supports W-CDMA to 3GPP in version 3.2.0 (FDD mode).This version of the 3GPP standard is also called release 1999.

References:

[1] 3GPP TS 25.211 Version 3.2.0 Physical channels and mapping of transport channels onto physical channels (FDD)
[2] 3GPP TS 25.213 Version 3.2.0 Spreading and modulation (FDD)
[3] 3GPP TS25.141 version 3.1.0

Note: *In addition to the latest version, the following versions can be found on the Rohde&Schwarz Internet site:*

- *2.20: last version which generates the NTT DoCoMo 1.0 signals*
- *3.00: last version that generates the ARIB 1.0 signals*
- *3.20: 3GPP FDD version 2.0.0 and 2.1.0*
- *3.30: 3GPP version 3.0.0*

WinIQSIM simulates W-CDMA 3GPP at the physical channel layer . The following description is therefore limited to this layer.

Table 8-1 W-CDMA parameters

Chip rate	3.84 Mcps
Channel types	Downlink : • Primary Common Pilot Channel (P-CPICH) • Secondary Common Pilot Channel (S-CPICH) • Primary Sync Channel (P-SCH) • Secondary Sync Channel (S-SCH) • Primary Common Control Phys. Channel (P-CCPCH) • Secondary Common Control Phys. Channel (S-CCPCH) • Page Indication Channel (PICH) • Acquisition Indication Channel (AICH) • Access Preamble Acquisition Indication Channel (AP-AICH) • Phys. Downlink Shared Channel (PDSCH) • Dedicated Physical Control Channel (DL-DPCCH) • Dedicated Phys. Channel (DPCH) Uplink : • Phys. Random Access Channel (PRACH) • Phys. Common Packet Channel (PCPCH) • Dedicated Physical Control Channel (DPCCH) • Dedicated Physical Data Channel (DPDCH)
Symbol rates	7.5 ksps, 15 ksps, 30 ksps to 960 ksps depending on channel type
Number of channels	In the downlink 4 base stations with up to 128 DPCHs and 11 special channels each In the uplink 4 mobile stations either with PRACH or PCPCH or DPDCH and up to 6 DPDCHs.
Frame structure	Time Slot: 0.667 ms, Radio Frame: 15 Time Slots = 10 ms, The structure of the frames depends on the symbol rate.
Scrambling Code	Downlink: 18 bit M sequence Uplink: 25 bit M sequence in long mode and 8 bit M sequence in short mode
Channelization Code for DPCH, DPDCH and DPCCH	"Orthogonal Variable Spreading Factor Code (OVSF)" Orthogonal matrix of *chip rate/symbol rate*

8.1.1 System Components

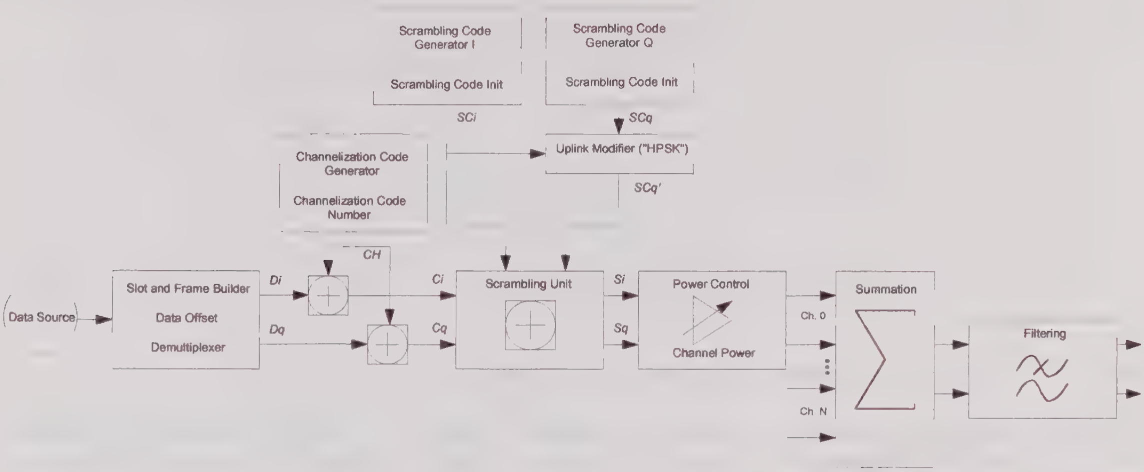


Fig. 8-1 Components of 3GPP W-CDMA transmission system

The individual functional blocks of the W-CDMA transmission system are described in the following.

8.1.1.1 Scrambling Code Generator

The scrambling code generator (previously called long code generator) is used to scramble the chip sequence as a function of the transmitter.
Depending on the link direction and mode (long or short), the structure and initialization regulation of the generator are different.

Downlink Scrambling Code Generator
This generator consists of a pair of shift registers from which the binary sequences for inphase and orthogonal component of the scrambling code are determined. Fig. 8-2 shows that the I component is produced as EXOR operation of the LSB outputs, whereas the register contents are first masked and read out for the Q component and then EXORed.

Note: *As an alternative, the Q component can also be determined using a register pair of the same structure, which is operated in idle state for a certain number of cycles before the scrambling code bits are taken. This I/Q offset is 131.072 in the downlink and 16.777.232 in the uplink long scrambling code generator of similar design. The implementation shown in Fig. 8-2 is the most efficient choice.*

Generator polynomials of the downlink scrambling code generators (3GPP 3.2.0)

Shift register 1	$x^{18}+x^{7}+1$
Shift register 2	$x^{18}+x^{10}+x^{7}+x^{5}+1$

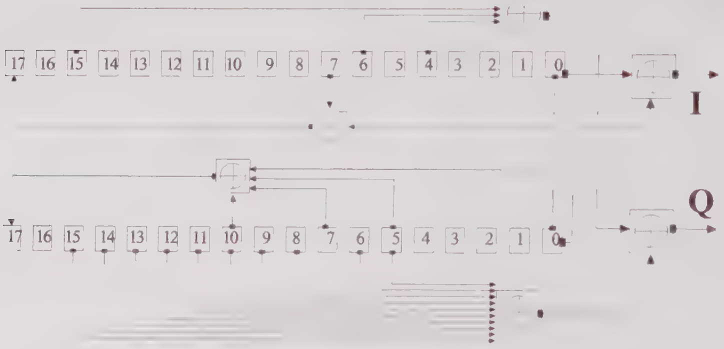


Fig. 8-2 Structure of downlink scrambling code generator

The shift registers are initialised by loading shift register 1 with "0...01" and shift register 2 completely with "1". In addition, shift register 1 is wound forward by n cycles, n being the scrambling code number or Scrambling Code (SC) for short.

After a cycle time of one radio frame the generators are reset, i.e. the above initialization is carried out again.

Uplink Scrambling Code Generator
In the uplink, a differentiation is made between two SC modes. The long SC, on the one hand, can be used for all types of channel. The short SC, on the other hand, can be used as an alternative to the long SC for all channels except PRACH and PCPCH.

a) Uplink Long Scrambling Code
Principally, the code generator of the long SC in the uplink is of the same structure as the SC in the downlink. However, the generator polynomials of the shift registers and the type of initialization are different.

Table 8-2 Generator polynomials of the uplink long scrambling code generator (3GPP 3.2.0)

Shift register 1	$x^{25}+x^{3}+1$
Shift register 2	$x^{25}+x^{3}+x^{2}+x+1$

The shift registers are initialized by allocating 1 to shift register 1 bit number 24 and the binary form of the scrambling code number n to bits 23 to 0. Shift register 2 is completely loaded with "1".
The read-out positions for the Q component are defined such that they correspond to an IQ offset of 16.777.232 cycles.
After a cycle time of one radio frame the generators are reset, i.e. the above initialization is carried out again.

b) Uplink Short Scrambling Code

The code generator of the short SC in the uplink consists of a total of 3 coupled shift registers.

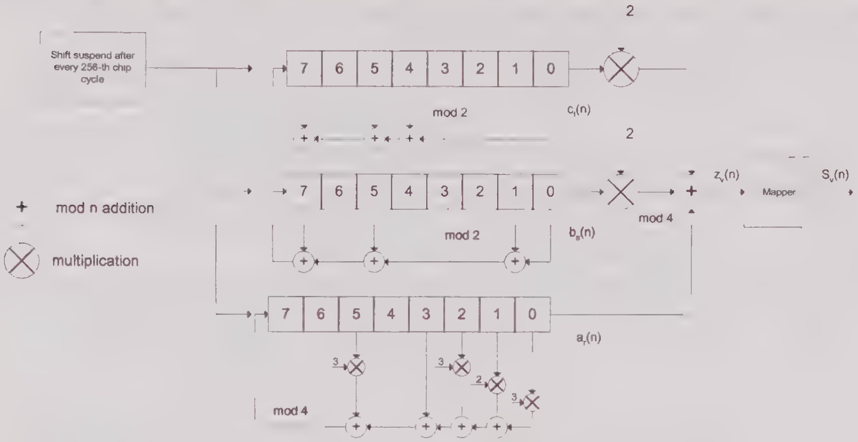


Fig. 8-3 Structure of uplink short scrambling code generator

Table 8-3 Generator polynomials of uplink short scrambling code generator (3GPP 3.2.0)

Shift register 1 (binary)	$x^8+x^7+x^5+x^4+1$
Shift register 2 (binary)	$x^8+x^7+x^5+x+1$
Shift register 3 (quaternary)	$x^8+x^5+3x^3+x^2+2x1$

The output sequences of the two binary shift registers are weighted with factor 2 and added to the output sequence of the quaternary shift register (Modulo 4 addition). The resulting quaternary output sequence is mapped into the binary complex level by the mapper block.

For initialization of the three 8-bit shift registers (in a modified way) the binary form of the 24-bit short SC number n is used, for details see section 4.3.2.3 in [2].

Table 8-4 Mapping of the quaternary output sequence into the binary IQ level

zv(n)	Sv(n)
0	+1 + j1
1	-1 + j1
2	-1 - j1
3	+1 - j1

c) Preamble Scrambling Code Generator

When generating the preambles of the PRACH and PCPCH a special SC is used. It is based on the Long SC described under a), however only the I component is taken and subsequently a pointer ($e^{j(PI/4 + PI/4 * k)}$, k=0 to 4095) modulated upon it.

Modification of the long and short scrambling code output sequence

The scrambling code sequence of the Q component is modified as standard to reduce the crest factor of the signal. Zero-crossings can thus be avoided for every second cycle. (This method is often called "HPSK").

For details see [2], section 4.3.2.1. WinIQSIM makes use of a decimation factor of 2.

Scrambling Unit

In the scrambling unit, the output of the scrambling code generator is linked with spread symbols. If the input signal and the scrambling code signal are interpreted as complex signal (C_i , C_q , SC_i , $SC_q' \in \{ -1, +1 \}$), the output signal is a complex multiplication of the two signals:

$$S_i + j\,S_q = (C_i + j\,C_q) * (SC_i + j\,SC_q')$$

and the following equations apply

$$S_i = C_i SC_i - C_q SC_q'$$
$$S_q = C_i SC_q' + C_q SC_i$$

The signal thus obtained can be interpreted as an QPSK signal with the following constellation diagram:

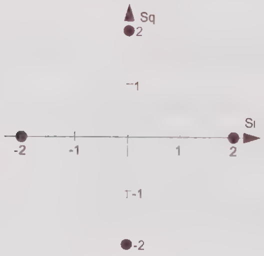


Fig. 8-4 Constellation diagram of a channel with 0 dB power

Note: *There are auxiliary conditions for some types of channels that may result in different constellation diagrams.*
If, for instance, symbols of the SCH are coded, a BPSK constellation is obtained without the scrambling unit. For an explanation of the different constellation diagrams see section 8.2.2.9.

Channelization Code Generator

The channelization code generator cyclically outputs a channel-specific bit pattern. The length of the cycle corresponds to the period of the source symbol to be spread, i.e. the number of bits corresponds to the spread factor. The spreading sequence for the I and Q branch is identical (real value). Spreading is a simple EXOR operation.

Two different channelization code generators are used depending on the type of channel:

Channelization Code Generator for all channels except SCH

Due to this channelization code the channel separation takes place in the sum signal. The channelization code number is the line of an orthogonal spreading matrix which is generated according to an iterative scheme ("OVSF").

Channelization Code Generator SCH

This generator replaces the one described above if the synchronisation code symbol of the SCH channels is spread.

The spreading matrix is replaced by a method that forms the spreading sequence from a hadamard sequence and a statistical sequence. For details see [2], section 5.2.3.1.

Data Source

The data source used in WinIQSIM is implemented at the physical layer. There is neither mapping of logical channels to physical channels nor is inner coding/outer coding performed. If the data source is to be implemented at a higher layer, this can be done with the aid of a file interface (see section 5.6).

Slot and Frame Builder

The bits from the data source are first entered into a frame structure. The frames are made up of two hierarchical levels:

Table 8-5 Hierarchical structure of 3GPP W-CDMA frames

Hierarchy	Length in ms	Remarks
Time Slot	0.667	Time slots are the basic unit in WinIQSIM. The sequence length is stated in time slots.
Radio Frame	10	After a radio frame, pilot symbols are repeated. One radio frame consists of 15 time slots. Also the length of a scrambling code cycle.

The configuration of the time slots depends on the channel type and symbol rate.
The following components are distinguished:

- Pilot sequence
  The pilot sequence characterizes the time slot position within the radio frame and also depends on the symbol rate, transmit diversity and the pilot length parameter.
  Channel types DPCH, S-CCPCH, DL-DPCCH, DPCCH, PRACH and PCPCH have a pilot sequence.
  The pilot sequence cannot be changed by the user.
- Synchronization code symbol
  The synchronization code symbol is the only symbol of the SCH.
  It is fixed to “11“.
- TPC symbol
  This symbol is used to control the transmit power. It is used in DPCH, DL-DPCCH and DPCCH.
  A bit pattern for the sequence of TPC symbols can be indicated as a channel-specific pattern.
- Data symbols
  These symbols carry the user information and are fed from the data source. They are used in DPCH, P-CCPCH, S-CCPCH,PDSCH, DL-DPCCH, DPDCH, PRACH and PCPCH.
- Signature
  The signature is used in PRACH and PCPCH. 16 fix bit patterns are defined of which the user may select one.
- TFCI
  The “Transport Format Combination Indicator“ is used in DPCH/DPCCH if the corresponding button of the interface (Base Station Configuration, see 8.2.2.5 / Mobile Station Configuration, see 8.2.2.6) is activated. In this case, a code sequence with the length of 30 is defined using this value and distributed among 15 subsequent time slots. In PRACH and PCPCH, the TFCI field is provided as standard.
- FBI
  Feedback indication bits are only used in DPCCH and PCPCH.

Timing Offset

The symbol stream can be shifted in time relative to the other channels. For this purpose a timing offset can be entered into the channel table, stating the range of shifting in multiples of 256 chips. Since WinIQSIM does not generate infinite symbol streams like a realtime system, this offset is implemented as a rotation.

Example for DPCH 30 ksps, 1 time slot, timing offset = 2;
2 x 256 chips = 512 chip offset;
4 data symbols shifting at a symbol rate of 30 ksps (1 symbol corresponds to 3.84 Mcps / 30 ksps = 128 chips).

previously:

11	11	11	11	00	01	10	11	00	10	01	11	11	01	00	01	10	11	01	00

afterwards:

10	11	01	00	11	11	11	11	00	01	10	11	00	10	01	11	11	01	00	01

The use of the timing offset usually causes a reduction of the crest factor of the total signal, since it is not always the same spreading chips (channelization chips) CH and scramble chips SC_i/SC_q' that are applied to the pilot sequences of the channels.

Demultiplexer

In the downlink, the symbol stream is divided into two bit streams D_i and D_q prior to processing in the spreading unit. The symbol stream is divided by allocating bits 1, 3, 5, to 2n-1 to the in-phase bit stream D_i, and bits 2, 4, 6, 2n to the quadrature bit stream D_q.
For the above example with timing offset:

$$D_i = 1\,1\,0\,0\,1\,1\,1\,1\,0\,0\,1\,1\,0\,1\,0\,1\,1\,0\,0\,0$$
$$Dq = 0\,1\,1\,0\,1\,1\,1\,1\,0\,1\,0\,1\,0\,0\,1\,1\,1\,1\,0\,1$$

(lefthand bit is always the first one in the time sequence)

In the uplink, independent data are used for the two paths.
PRACH/PCPCH : Preamble : signature parallel to I and Q
Message part : data to I, pilot, TPC and TFCI to Q
DPCCH : all bits to I, Q always unused
DPDCH : all bits are always to I **or** Q (dependent on channel number), the other path is unused.

Power Control

After spreading and scrambling, a channel-specific power factor p is applied to the signal. A value of -6 dB therefore results in half the level (or ¼ power) and the following diagram (DPCH):

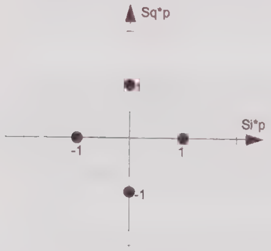


Fig. 8-5 Constellation diagram of a channel with –6 dB power

Summation

After application of the channel power, the components of the individual channels are summed up.
The constellation diagram of the sum signal is obtained by superposition of the diagrams of the individual channels. If the signal consists of two channels with a power of -6 dB and -12 dB and each channel contains independent source data (DPCH), the following constellation diagram is obtained:

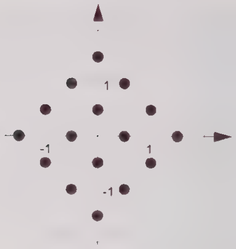


Fig. 8-6 Constellation diagram of a 3GPP W-CDMA signal with two DPCH channels

Filtering
An unfiltered spread signal is obtained after summation. Due to filtering the number of samples is increased by the oversampling factor and band-limiting is performed.

Multi Code
3GPP W-CDMA supports multi-code transmission for downlink-dedicated physical channels (DPCH) .
This form of transmission is used for channels intended for the same receiver, i.e. those receivers that belong to a radio link. The first channel of this group is used as a master channel.
Shared parts (pilot, TPC and TCFI) are spread for all channels using the spreading code of the master channel.

Note: *Instead of changing the spreading code within a slot several times, the master code rather than the shared parts can be sent at higher power. The other channels then have to be blanked out correspondingly.*

8.1.2 Compressed Mode

To enable handover of a mobile station from a 3GPP FDD base station to another base station, (3GPP FDD, 3GPP TDD or GSM) at a different frequency, transmission and reception of the 3GPP FDD signal must be interrupted for a short time. During this time, the mobile station changes to the frequency of the new base station, for example to measure the receive level of this station or read system information.
To transmit a consistently high data volume also in the remaining (shorter) period of time, the data is compressed. This can be done by halving the spread factor (SF/2 method) or reducing error protection (puncturing method). In both cases, transmit power in the ranges concerned is increased to maintain adequate signal quality.
Apart from these two methods, there is also the method of "higher layer scheduling". With this method, transmission of the data stream is stopped during the transmission gap. This method is suitable for packet-oriented services; it involves no power increase (power offset) in the active ranges.
The compressed mode is used both in the uplink and the downlink.
The signal generated can be divided into three subranges:

Transmission gaps
A transmission gap has a maximum length of 14 slots. Since at least eight active slots must be sent per frame, gaps comprising seven slots and more have to be distributed over two neighbouring frames.
The transmitted signal consists of max. two patterns that are sent alternately. Each pattern comprises two transmission gaps.

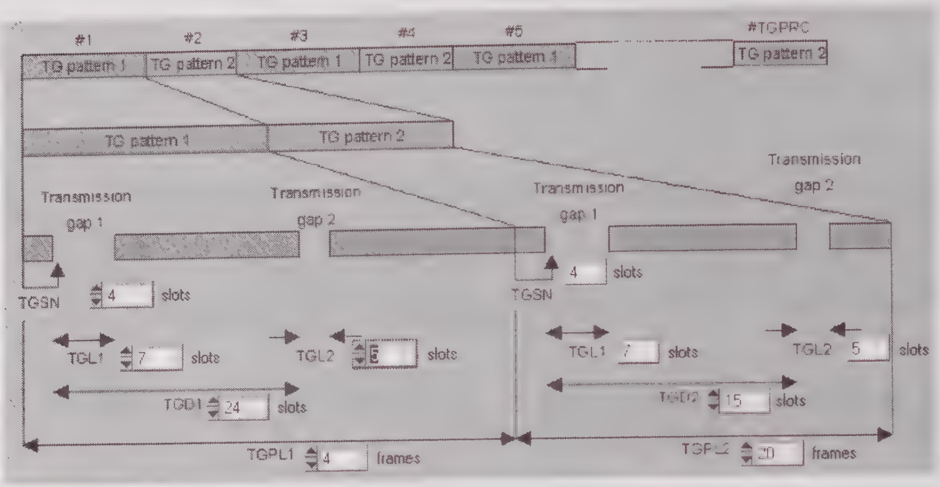


Fig. 8-7 Distribution of transmission gaps in a compressed mode signal

The above diagram includes all parameters necessary to define the transmission gaps in the signal. Meaning of abbreviations:

TGSN:	transmission gap slot number
TGL1:	transmission gap length 1
TGD1:	transmission gap distance 1
TGL2:	transmission gap length 2
TGPL1:	transmission gap pattern length 1
TGD2:	transmission gap distance 2
TGPL2:	transmission gap pattern length 2

In the above example, the signal (or more precisely: the pattern of transmission gaps) is repeated every 24 frames.

Compressed ranges

All slots of a frame that are not blanked are compressed. If the transmission gap is transmitted within one frame (single-frame method), an envelope as shown by the diagram below is obtained:

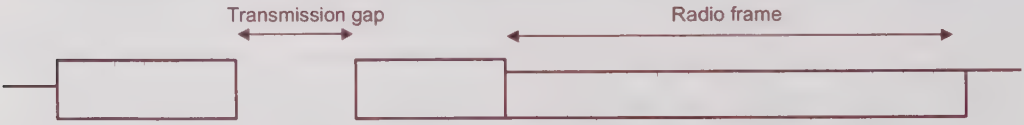


Fig. 8-8 Envelope of compressed mode signal with single-frame method

If the transmission gap is distributed over two neighbouring frames, all slots of the two frames that are not blanked are compressed:

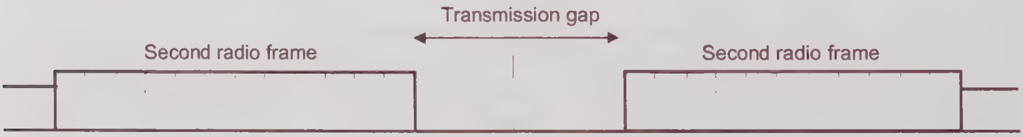


Fig. 8-9 Envelope of compressed mode signal with double-frame method

A different slot format, usually with a higher number of pilot bits, is used in the compressed ranges. The transmit power can be increased (CM power offset mode) automatically or manually by defining a power offset.

Non-compressed ranges
Frames containing no transmission gaps are sent with the same slot format and the same power as in the non-compressed mode.

Transmission of TPC and pilot in transmission gaps in downlink
For 3GPP FDD radiocommunication to operate, the mobile station receiver requires information in

- the pilot field PL for synchronization and channel estimation and in
- the power control field TPC for control of the mobile station transmit power.

To keep the period during which no channel estimation takes place as short as possible, the pilot is sent in the last slot of each transmission gap:

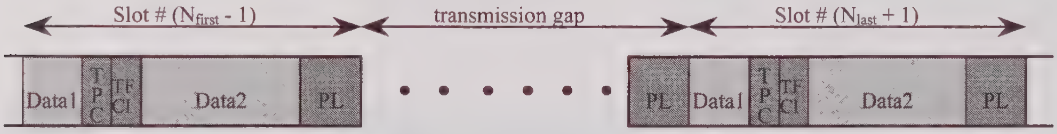


Fig. 8-10 Transmission of last pilot of transmission gap in downlink (type A frame structure)

Optionally, the first TPC field of the transmission gap can be sent in addition, which yields the type B frame structure:

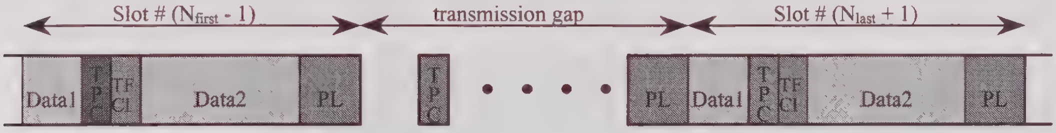
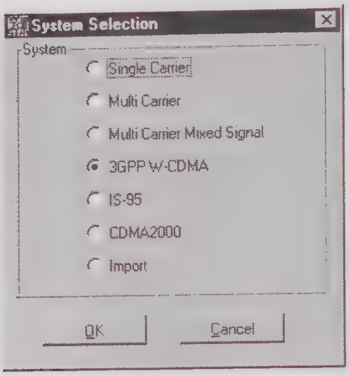


Fig. 8-11 Transmission of first TPC field and last pilot of transmission gap in downlink (type B frame structure)

8.2 Generation of 3GPP W-CDMA Signals with WinIQSIM

To generate a W-CDMA signal complying with the standard 3GPP 3.0.0, the 3GPP W-CDMA system must be selected first.



System Selection

System

○ Single Carrier
○ Multi Carrier
○ Multi Carrier Mixed Signal
● 3GPP W-CDMA
○ IS-95
○ CDMA2000
○ Import

Fig. 8-12 System selection 3GPP W-CDMA

The system can be selected in the File/New... or System! menu.
The differences between the two methods are described in sections 5.22.1 and 5.23.

The 3GPP W-CDMA block diagram is based on the single carrier system. The data source block has been enhanced and the modulation block replaced by the W-CDMA configuration block.

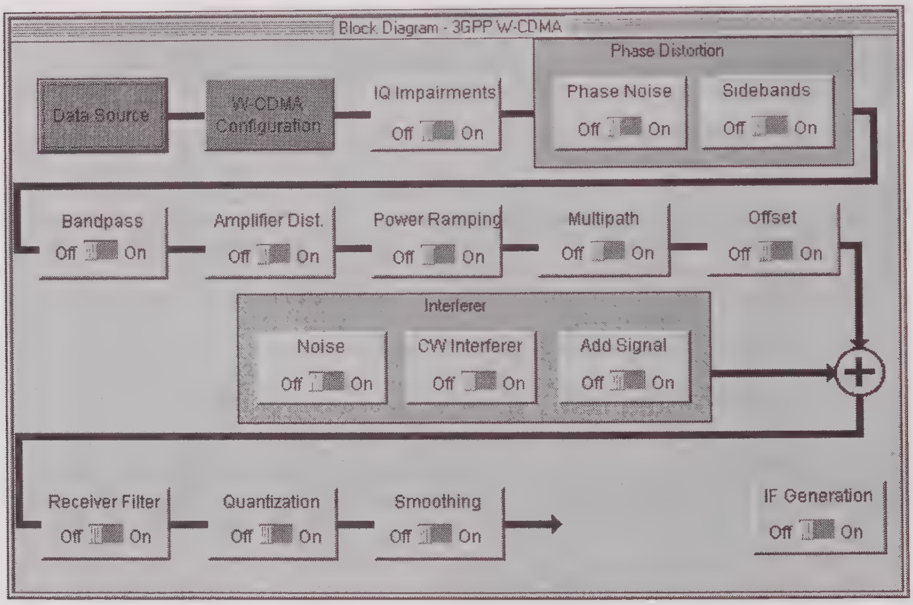


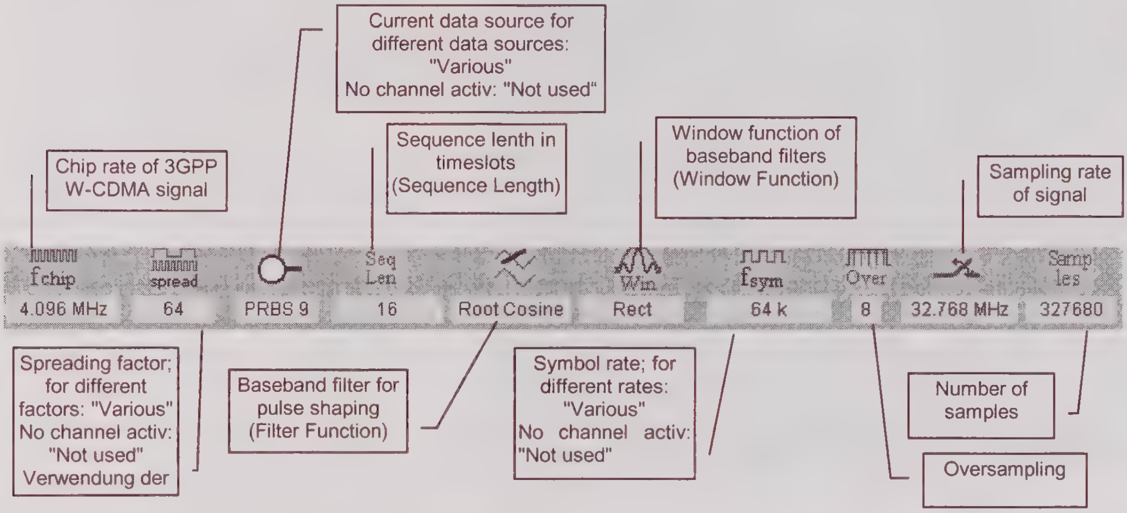
Fig. 8-13 Block diagram of the 3GPP W-CDMA system

The data source block corresponds to that of the multicarrier system. For description of the data source see section 7.2.

8.2.1 Status Line

The main parameters of the 3GPP W-CDMA transmission system are displayed in the status line below the toolbar of the main panel. The set parameters can thus be seen at a glance.

The status line contains icons for the different parameters; below the icons the current parameter values are indicated. The following illustration shows the status line of the 3GPP W-CDMA system with the parameters assigned to the icons.



4.096 MHz | 64 | PRBS 9 | 16 | Root Cosine | Rect | 64 k | 8 | 32.768 MHz | 327680

Current data source for different data sources: "Various" No channel activ: "Not used“

Chip rate of 3GPP W-CDMA signal

Sequence lenth in timeslots (Sequence Length)

Window function of baseband filters (Window Function)

Sampling rate of signal

Spreading factor; for different factors: "Various" No channel activ: "Not used" Verwendung der

Baseband filter for pulse shaping (Filter Function)

Symbol rate; for different rates: "Various" No channel activ: "Not used"

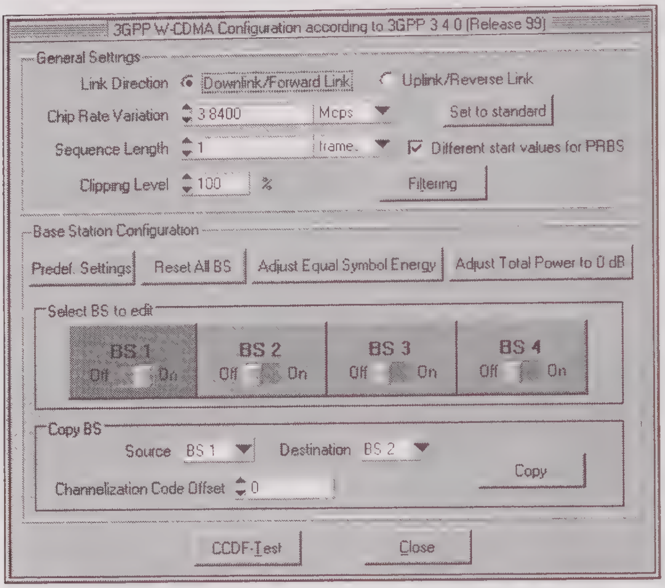
Number of samples

Oversampling

Fig. 8-14 Status line of 3GPP W-CDMA system

8.2.2 3GPP W-CDMA Configuration Panel

All parameters that are required for the definition of a 3GPP W-CDMA signal (except the definition of the data sources and impairments) can be accessed via the 3GPP W-CDMA Configuration panel. Depending on the selected link direction, the panel can look like the following:


3GPP W-CDMA Configuration according to 3GPP 3.4.0 (Release 99)

General Settings

Link Direction ● Downlink/Forward Link ○ Uplink/Reverse Link

Chip Rate Variation 3.8400 Mcps

Sequence Length 1 frame

☑ Different start values for PRBS

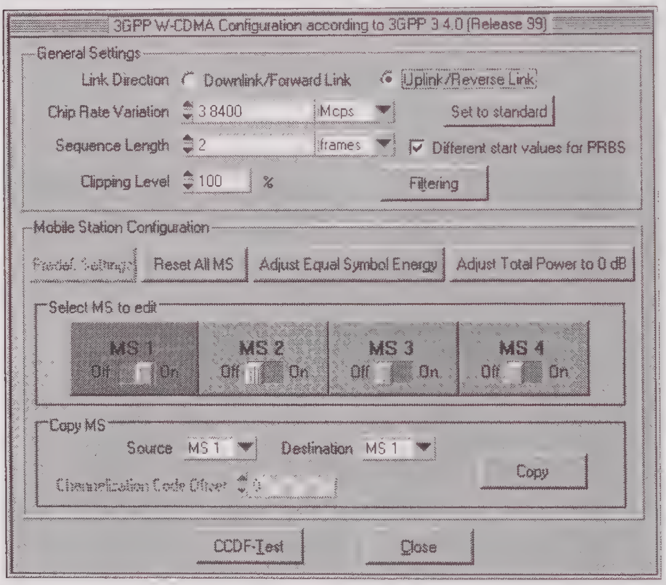
Clipping Level 100 %

Copy BS

Source BS 1 Destination BS 2

Channelization Code Offset 0

Fig. 8-15 3GPP W-CDMA configuration panel in downlink


3GPP W-CDMA Configuration according to 3GPP 3.4.0 (Release 99)

General Settings

Link Direction ○ Downlink/Forward Link ● Uplink/Reverse Link

Chip Rate Variation 3.8400 Mcps

Sequence Length 2 frames

☑ Different start values for PRBS

Clipping Level 100 %

Copy MS

Source MS 1 Destination MS 1

Channelization Code Offset 0

Fig. 8-16 3GPP W-CDMA configuration panel in uplink

8.2.2.1 General Settings

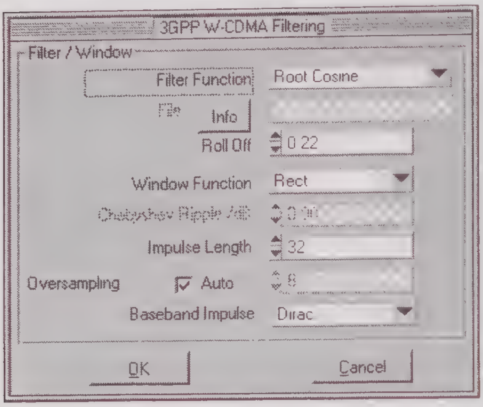
The following parameters are defined in the General Settings panel:

- **Link Direction**
  Downlink/forward link, i.e. from the base station to the mobile station, or uplink/reverse link, i.e. from the mobile station to the base station. The lower section of the panel depends on the link direction. In the downlink mode, the lower section is used to configure the base stations and in the uplink the mobile stations.
- **Chip Rate Variation**
  This parameter permits to change the output chip rate (i.e. the rate of spread symbols as used for signal output by AMIQ) as against the standard chip rate of 3.84 Mcps . This value is set as standard to 3.84 Mcps and can be reset to this value at any time using the **Set to standard** button.
- **Sequence Length**
  This is for setting the length of the signal to be generated. The length can be entered in slots (2560 chips, 0.667 ms) or frames (38400 chips, 10 ms).
  When the unit of length is changed, the displayed numerical value is automatically converted to the new unit (1 frame corresponds to 15 slots). When switchover is made from slots to frames, the value is rounded to the next higher integer number of frames.
- **Different start values for PRBS**
  If this button is active, the PRBS generators of the individual channels are initialized with different start values. As a result, all channels are calculated with independent source data.

  Note: *This button is only effective for the data source with the name "Data Source PRBS". If for example the data source with the designation "Data Source 0" is used with PRBS16, the button is ignored, i.e. all channels using Data Source 0 are calculated with identical PRBS bit sequences!*
- **Clipping Level**
  Setting the clipping value relative to the highest peak in percent. The value range is 1 to 100 %. A value of 100% means that the signal is not clipped. Clipping reduces the crest factor. For more detailed information on the use of this parameter refer to section 8.3.3.

8.2.2.2 Filtering

The generated raw chips are subjected to baseband filtering which is implemented equivalent to the single carrier system.



Filter Function: Root Cosine

Roll Off: 0 22

Window Function: Rect

Impulse Length: 32

Oversampling ☑ Auto 8

Baseband Impulse: Dirac

Fig. 8-17 3GPP W-CDMA Filtering

The description of the individual parameters can therefore be found in section 5.8 Modulation Setting panel.

For filtering W-CDMA signals, parameters described in Fig. 8-17 are recommended.

8.2.2.3 Base Station/Mobile Station Configuration

With the 3GPP W-CDMA system, up to 512 code channels (+ 11 special channels per station) can be simulated in the downlink. The 512 channels are distributed among 4 base stations with up to 128 channels. The large number of channels can thus be clearly processed and the simulation of scenarios consisting of several base or mobile stations is possible. The system can also be configured such that several BS are combined to one. A BS with more than 128 code channels can thus be simulated (also see Copy BS/MS below).

Due to the extension to 3GPP version 3.0.0, the operation in the uplink has been changed. In contrast to the 3GPP versions 2.0.0 and 2.1.0, there is no longer the large channel table with 128 DPDCHs. A mobile station now features a maximum of 6 DPDCHs the parameters of which are defined by the standard to a large extent. To achieve a very clear and simple operation, a distinction is made between 3 modes in the uplink (PRACH only, PCPCH only and DPCCH + DPDCH). Only the relevant parameters will then be visible in the mode selected. However, it is still possible to simulate a signal scenario consisting of up to 4 mobile stations.

For a detailed description of some possible scenarios and for modelling them in WinIQSIM see 8.3.5.

8.2.2.3.1 Common Setting of all Basis Stations/Mobile Stations

The Base Station/Mobile Station Configuration comprises several buttons the function of which will now be described.

Predef. Settings.: If this button that is only accessible in the downlink is selected, an operating panel for defining parameterizable predefined settings is opened. Complex scenarios can thus be defined very easily. For further information see section 8.2.2.4.

Reset All BS: All base stations are reset to predefined settings. For reset settings see table below.

Table 8-6 Reset values for base stations

Common parameters of BS	**Reset values (BS 1, BS 2, BS 3, BS 4)**
State	Off for all BS
Scrambling Code	0 for all BS
Scrambling Code Off	switch off, i.e. scrambling code active
2nd Search Code Group	0 for all BS
Use TFCI	Off for all BS
TFCI	0 for all BS
(Mis-)Use TPC for output power control	Off for all BS
Power Step	0 dB for all BS
TPC Read Out Mode	continuous
Number of PI per frame	18
Transmit Diversity	Off for all BS
Parameters of DPCH channels	**Reset value (BS 1, BS 2, BS 3, BS 4)**
Symbol Rate	15 ksps
Channelization Code Number	0 for all channels
Power	0 dB for all channels
Data Source	PRBS for all channels
TPC Pattern	"0“ for all channels
Timing Offset	0 for all channels
Multi Code State	Off for all channels
Pilot Length	4 bits
State	Off for all channels

Reset All MS: All mobile stations are reset to predefined settings. For reset settings see table below.

Table 8-7 Reset values for mobile stations

Common parameters of MS	**Reset value (MS 1, MS 2, MS 3, MS 4)**
State	Off for all MS
Mode	DPCCH + DPDCH
Scrambling Code	0 for all BS
Scrambling Code Mode	Long SC
TPC Pattern	"0" for all MS
TPC Read Out Mode	continuous
Parameter DPCCH	**Reset value (MS 1, MS 2, MS 3, MS 4)**
Symbol Rate	15 ksps (fix)
Timing Offset	4 (fix)
Use TFCI	Off for all MS
TFCI	0 for all MS
FBI	Off for all MS
FBI pattern	"0" for all MS
(Mis-)Use TPC for output power control	Off for all BS
Power Step	0 dB for all BS
Power	0 dB for all MS
Parameter DPCCH	**Reset value (MS 1, MS 2, MS 3, MS 4)**
State	On
Overall Symbol Rate	30 ksps
Channel Power	0 dB
Data Source	PRBS for all channels

Adjust Equal Symbol Energy: The power of the individual code channels is set so that the energy of the useful symbols is equal prior to spreading. Since spreading accelerates processing by the spreading factor, the transmit power of a code channel can be reduced by this factor to obtain the same characteristics as before the spreading. The channel power of the individual code channels is set so that the product of the spreading factor and transmit power is constant. Channels with a high spreading factor are weighted with smaller transmit power than those with a small spreading factor. In the uplink, only the DPDCHs and DPCCHs are considered in this case (PRACH and PCPCH are active only for a limited period of time).

Adjust Total Power to 0 dB: The power of the individual code channels is set so that the sum power of all active channels is 0 dB. The set power differences of all channels remain the same but the total power is normalised to 0 dB. This mode can be used to send the individual code channels at the power indicated in WinIQSIM from Signal Generator SMIQ (with a set effective transmit power of 0 dB). In the uplink, only the DPDCHs and DPCCHs are considered in this case (PRACH and PCPCH are active only for a limited period of time).

Select BS/MS to edit: In this section, the base stations/mobile stations are indicated as blocks. They can be switched on or off. Active BS/MS are indicated as green blocks, passive BS/MS as grey blocks. It can thus be seen at a glance which stations are currently active. If the parameters of a base station/mobile station are to be edited, the corresponding BS/MS block is to be clicked. A setting window to configure the BS/MS is opened (also see sections 8.2.2.5and 8.2.2.6).

Copy BS/MS: This section allows to copy the configuration of one BS/MS for another BS/MS. Select the source BS/MS (to be copied) in the field Source and the destination BS/MS (to be overwritten) in the field Destination. Start copying by pressing the Copy button. It is thus possible to generate a scenario from several BS/MS after having configured a BS/MS. After copying, only the BS/MS specific parameters such as Scrambling Code Init of BS/MS have to be changed to simulate different BS/MS.
With parameter Channelization Code Offset that is only accessible in downlink, WinIQSIM can be easily configured such that a signal of a BS is simulated with more than 128 channels. When copying, the channelization code number of each channel of the new BS is increased by the value set in the field Channelization Code Offset as against the reference channel in the source BS.

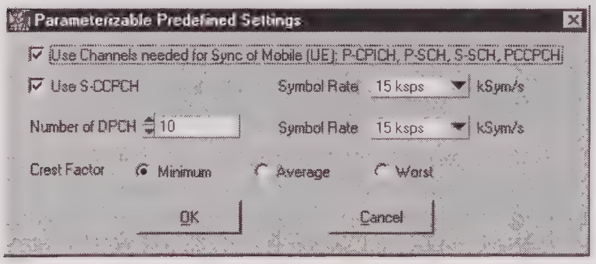
Example: *If 256 channels with continuous channelization codes from 0 to 255 are to be generated in a BS, first configure BS 1 with 128 channels and then channelization codes 0 to 127. In section Copy BS then set BS 1 as source, BS 2 as destination and 128 as Channelization Code Offset. Start to copy the setting by pressing the Copy button.*

CCDF Test: This button is used to open a window in which the so-called "Complementary Cumulative Distribution Function" is displayed. For further information see **section** 8.2.2.7.

Close: When this button is selected, the 3GPP W-CDMA Configuration panel is closed.

8.2.2.4 Parameterizable Predefined Settings

This panel is used to define parameterizable predefined settings and is only accessible in downlink. Complex scenarios can thus be defined very easily.



☑ Use Channels needed for Sync of Mobile (UE): P-CPICH, P-SCH, S-SCH, PCCPCH

☑ Use S-CCPCH   Symbol Rate 15 ksps kSym/s

Number of DPCH 10   Symbol Rate 15 ksps kSym/s

Crest Factor ● Minimum ○ Average ○ Worst

Fig. 8-18 Parameterizable Predefined Settings Panel Downlink

The option **Use Channels needed for Snyc of Mobile (UE): P-CPICH, P-SCH, S-SCH, PCCPCH** permits to select whether the signal is to contain the channels required by a mobile for synchronization.
In addition, you can select whether it is to contain a S-CCPCH and its symbol rate.
The number of DPCH channels and their symbol rates that are to be used in the scenario can also be selected. In this case, the maximum number of DPCH channels depends on the selected symbol rate.

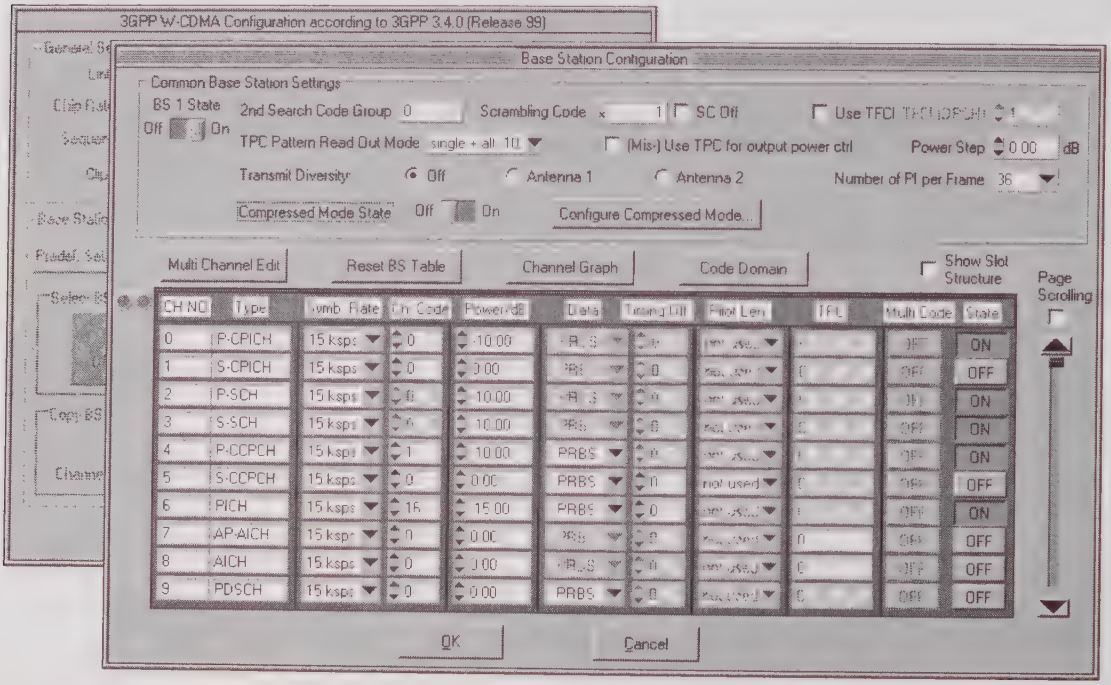
$$\mathbf{max\_number\_of\_DPCH} = \frac{\mathbf{chip\_rate}}{\mathbf{symbol\_rate}} = \frac{\mathbf{3.84Mcps}}{\mathbf{symbol\_rate}}$$

Section **Crest Factor** allows to specify whether the signal scenario is to be set to minimum, average or worst crest factor. WinIQSIM automatically selects the channel parameters for the required scenario by varying the timing offset and channelization code of the code channels.
When clicking the OK button, the parameters and the channel tables of the individual base stations are automatically configured as determined by the parameters indicated above. The correct number of base stations as required for generating the desired channel number is activated.

Example: *If a signal with 250 DPCH channels is to be generated, BS 1 is automatically allocated with 128 channels and BS 2 with the remaining 122. BS 1 and BS 2 are switched on and configured with the same base station parameters. Only the channel tables of the two base stations with the code channel-specific settings differ.*

8.2.2.5 Base Station Configuration

When clicking one of the base station blocks in the 3GPP W-CDMA Configuration panel, the Base Station Configuration panel is opened. The 3GPP W-CDMA Configuration panel is also displayed but is dimmed since the two windows are interrelated in many ways. The 3GPP W-CDMA configuration parameters can still be read but not changed. As soon as the Base Station Configuration panel is closed (OK or Cancel), the 3GPP W-CDMA Configuration panel is enabled again.


3GPP W-CDMA Configuration according to 3GPP 3.4.0 (Release 99)
Base Station Configuration
Common Base Station Settings
Multi Channel Edit
Reset BS Table
Channel Graph
Code Domain
☐ Show Slot Structure
Page Scrolling
OK
Cancel

BS 1 State: Off / On
2nd Search Code Group: 0
Scrambling Code: 1
☐ SC Off
☐ Use TFCI
TPC Pattern Read Out Mode: single + all 10
☐ (Mis-) Use TPC for output power ctrl
Power Step: 0.00 dB
Transmit Diversity: ● Off ○ Antenna 1 ○ Antenna 2
Number of PI per Frame: 36
Compressed Mode State: Off / On
Configure Compressed Mode...

CH NO	Type	Symb. Rate	Ch. Code	Power/dB	Data	Timing Off	Pilot Len	TFCI	Multi Code	State
0	P-CPICH	15 ksps	0	-10.00	[illegible]	[illegible]	[illegible]	[illegible]	OFF	ON
1	S-CPICH	15 ksps	0	0.00	PRBS	0	not used	0	OFF	OFF
2	P-SCH	15 ksps	0	-10.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	ON
3	S-SCH	15 ksps	[illegible]	-10.00	PRBS	0	not used	0	OFF	ON
4	P-CCPCH	15 ksps	1	-10.00	PRBS	[illegible]	[illegible]	[illegible]	OFF	ON
5	S-CCPCH	15 ksps	0	0.00	PRBS	0	not used	0	OFF	OFF
6	PICH	15 ksps	16	-15.00	PRBS	0	[illegible]	[illegible]	OFF	ON
7	AP-AICH	15 ksps	0	0.00	PRBS	0	not used	0	OFF	OFF
8	AICH	15 ksps	0	0.00	[illegible]	[illegible]	[illegible]	0	OFF	OFF
9	PDSCH	15 ksps	0	0.00	PRBS	0	not used	0	OFF	OFF

Fig. 8-19 Base Station Configuration Panel

8.2.2.5.1 Common Base Station Settings

This section of the panel allows to set the parameters that are valid for the complete base station.

BS State: The complete base station can be switched on or off.

2nd Search Code Group: This parameter indicates " Allocation of SSCs for secondary SCH" described in the 3GPP standard [2]. This table allocates a special spreading code to each synchronization code symbol in the frame of the S-SCH. The value range of the parameter is 1 to 63.
This parameter cannot be edited and is calculated from the scrambling code automatically.

Scrambling Code:
The scrambling code generator (previously called Long Code Generator) is used to scramble the chip sequence as a function of the transmitter. For more detailed information on the generator structure and initialization refer to section 8.1.1.1.

The value range of the scrambling code is 0 to 5FFF or 2475 in decimal notation.
The division into primary and secondary or left and right alternative scrambling codes is described in [2], section 5.2.2.

SC Off: if this switch is active, the scrambling code generator is deactivated ($SC_i = SC_q = 0$).

Use TFCI: You can decide whether the DPCH channels are to use the TFCI field. If this option is selected, the TFCI field is enabled.

TFCI: The TFCI (Transport Format Combination Indicator) field contains information about the used symbol rate combinations in the DPCHs. The TFCI value range is from 0 to 1023.

TPC Pattern Read Out Mode: With W-CDMA, the TPC bits are used to signal to the partner that the transmission power is increased or reduced. You can define the TPC field contents for the BS channels irrespective of each other in the channel table further down in this panel. Using the parameter TPC Pattern Read Out Mode, you can determine how this bit pattern is to be used. A distinction is made between the following modes:

- **Continuous:** A bit is taken for each slot from the up to 16-bit long bit pattern for the Transmitter Power Control field of the slots and entered in the bit stream several times (depending on the symbol rate). The specified bit pattern is used cyclically.
- **Single + All 0:** A bit is taken for each slot from the up to 16-bit long bit pattern for the Transmitter Power Control field of the slots and entered the bit stream several times (depending on the symbol rate). The specified bit pattern is used once, then the TPC sequence is continued with 0 bits.
- **Single + All 1:** A bit is taken for each slot from the max. 16-bit long bit pattern for the Transmitter Power Control field of the slots and entered in the bit stream several times (depending on the symbol rate. The specified bit pattern is used once, then the TPC sequence is continued with 1 bit.
- **Single + alt. 01:** A bit is taken for each slot from the up to 16-bit long bit pattern for the Transmitter Power Control field of the slots and entered the bit stream several times (depending on the symbol rate. The specified bit pattern is used once, then the TPC sequence is continued with 0 and 1 bits alternately (multiplied depending on the symbol rate, i.e. e.g. 00001111).
- **Single + alt. 10:** A bit is taken for each slot from the up to 16-bit long bit pattern for the Transmitter Power Control field of the slots and entered in the bit stream several times (depending on the symbol rate. The specified bit pattern is used once, then the TPC sequence is continued with 1 and 0 bits alternately (multiplied depending on the symbol rate, i.e. e.g. 11110000).

The different modes can be used e.g. to set a mobile to a specific output power (e.g. with pattern 11111) and then let it oscillate about this power (using **Single + alt. 01** or **Single + alt. 10**). Thus power measurements on the mobile can be performed (with a quasi-constant power). In conjunction with the option **(Mis-)Use TPC for output power control** (see below) the TPC Read Out Mode can also be used for generation of various output power profiles.

(Mis-)Use TPC for output power control / Power Step : If this field is marked, the given pattern is misused to vary the inherent transmit power versus time. A bit of this pattern is used per slot to increase (bit = 1) or decrease (bit = 0) the channel power by the given power step. The upper limit is at 0 dB and the lower at –60 dB.

Note: *Note that the power change (as specified in the standard) is always performed at the beginning of the pilot field of the slot.*

The following envelope is obtained at a channel power of 0 dB, with a power step of 1.0 dB, the pattern "001110100000011" and TPC Pattern Read Out Mode **Continuous**:

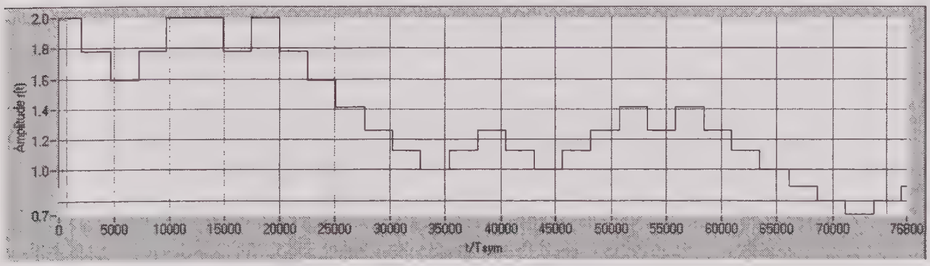


Fig. 8-20 Dynamic change in channel power (continuous)

The following envelope is obtained with the same TPC pattern, but TPC Pattern Read Out Mode **Single + alt. 01**:

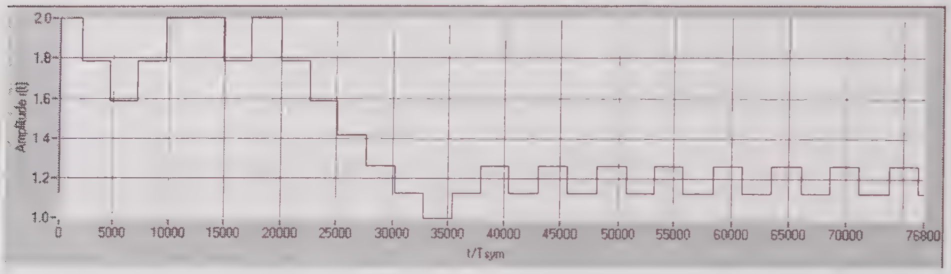


Fig. 8-21 Dynamic change in channel power (single + alt. 01)

Transmit Diversity : The 3GPP standard describes different forms of transmit diversity. In the present version of WinIQSIM, a fixed diversity scheme is assigned to each channel type:
DPCH, PCCPCH, SCCPCH and PDSCH: STTD (Space time block coding transmit antenna diversity)
Primary and Secondary SCH : TSTD (Time switched transmit diversity for SCH)
The two schemes are explained in detail in [1], section 5.3.1.

If transmit diversity is desired, the antenna the signal of which is to be simulated can be specified.

Number of PI per Frame : You can define the number of page indicators per frame in the Page Indication Channel (PICH). The value range is 18, 36, 72, 144.

Compressed Mode State : You can define whether the signal is to be simulated in compressed mode (ON) or non-compressed mode (OFF).

Configure Compressed Mode ... : This button starts the Compressed Mode Configuration panel. The settings in this panel are described in section 8.2.2.9.

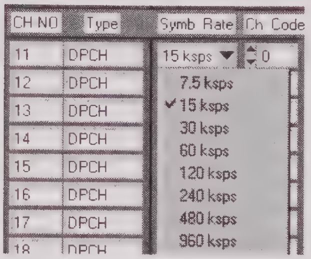
8.2.2.5.2 Channel Table of a Base Station

Most of the base station configuration panel is filled by the scrollable channel table. The table elements can be directly edited or changed. The individual table columns and the changeable parameters are described in the following.

CH NO: A continuous channel number starting with 0 is shown in the first column. A base station in WinIQSIM consists of 11 special channels such as e.g. P-CPICH, S-CPICH and DL-DPCCH and up to 128 DPCHs which can be set irrespective of each other.

Type: The type of channel is shown here. The first 11 code channels in the table are occupied for the special channels P-CPICH to DL-DPCCH. All other code channels are DPCHs. The channel type is a pure display parameter and cannot be edited.

Symb. Rate: This column allows to allocate the symbol rate to be used to a code channel. Depending on the channel type, the value range of the symbol rate is changed. A symbol rate of 15 ksps of the 3GPP standard is allocated to the P-CPICH, for example. For a DPCH, however, all symbol rates between 7.5 ksps and 960 ksps are available.



CH NO	Type	Symb Rate	Ch Code
11	DPCH	15 ksps	0
12	DPCH		
13	DPCH		
14	DPCH		
15	DPCH		
16	DPCH		
17	DPCH		
18	DPCH		

Fig. 8-22 Symbol rates of a DPCH

Ch. Code: The channelization code (previously called spreading code number) is selected here. The code channel is then spread with the channelization code (spreading code) thus determined. The value range of the channelization code depends on the symbol rate of the channel. A fixed channelization code is allocated to a few channels as standard (the P-CPICH e.g. always uses the channelization code 0).

The maximum value range extends from 0 to $\frac{\mathbf{chip\_rate(=3.84Mcps)}}{\mathbf{symbol\_rate}}$.

Power/dB: This column allows to set the power of the code channel. The value range of the channel power is from –60 dB to 0 dB.

- **Data**: Selection of one of the four data sources data 0, data 1, data 2 or PRBS.

For definition of data sources see 7.2. In the case of channel types, which do not contain any data fields (e.g. P-SCH), the Data field is not accessible.

Timing Offset: A value greater than 0 causes the source symbols to be shifted prior to spreading. An offset of 1 for instance is recommended to obtain a low crest factor.
The absolute starting time of the frames (slot 0) is shifted relative to the beginning of the scrambling code sequence by T_{Offset} * 256 chips. This means that the resolution of the timing offset is always 256 chips, irrespective of the symbol rate. The effect of the timing offset is explained in the following. The value range of the timing offset is from 0 to 149. The parameter is accessible for DPCHs only.

The illustration below shows the effect of the timing offset parameter. For various scenarios, the scrambling code sequence is shown in time relation to the data slots and to a reference time t_0 (starting from t_0 the signal is calculated in WinIQSIM).

a) Timing offset is not used (T_{Offset} = 0). The beginning of the frame (slot 0) and the beginning of the scrambling code period are synchronous with starting point t_0.

b) Timing offset is used (T_{Offset} > 0). The absolute starting time of the frames (slot 0) is shifted relative to the reference time t_0 by T_{Offset} * 256 chips. The beginning of the scrambling code sequence is still synchronous with reference time t_0. The beginning of the scrambling code period and the frame (slot 0) are no longer synchronous.

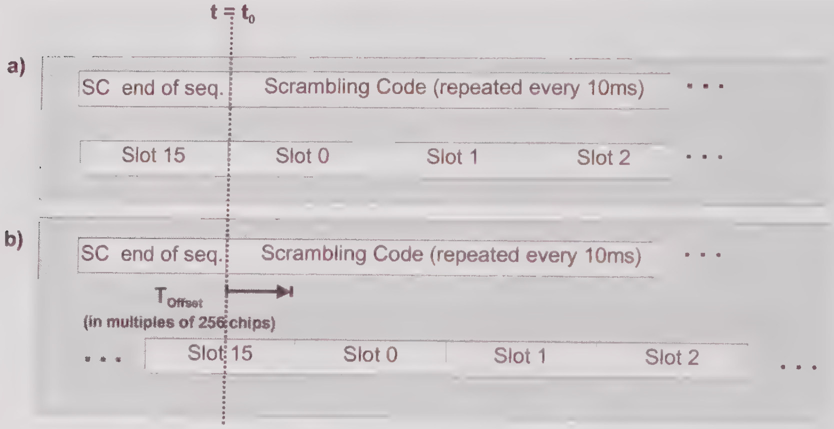

t = t0
a)
SC end of seq.
Scrambling Code (repeated every 10ms)
Slot 15
Slot 0
Slot 1
Slot 2
b)
SC end of seq.
Scrambling Code (repeated every 10ms)
TOffset
(in multiples of 256 chips)
Slot 15
Slot 0
Slot 1
Slot 2

Fig. 8-23 Effect of timing offset

Pilot Length: You can select the length of the pilot field in the slot structure of a channel. The value range of this parameter depends on the symbol rate (2 bits to max. 16 bits). To achieve a constant length of the slot the data fields are lengthened or shortened depending on the pilot length as defined in the standard. The field is enabled for DPCHs only.

TPC: A 16-bit long pattern for the transmitter power control field of the slots can be entered here. A bit is taken from this pattern and entered several times (depending on the symbol rate) in the bit stream. The given bit pattern is used as a function of the current TPC Pattern Read Out Mode (see above in section 8.2.2.5.1).

With channels **AP-AICH** and **AICH**, you can use the TPC field for definition of the Acquisition Indicator AI_i for weighting the up to 16 AICH signature patterns ($b_0 - b_{15}$) (see [1] section 5.3.3.6 Table 204). The following conditions apply: The length of the TPC pattern determines the number of AICH vectors used (the vectors w_1 to $w_{\text{Pattern Length}}$ are used automatically).

- The i-th bit in the pattern controls the i-th AICH vector b_i.
- A “0 bit“ in the pattern leads to a weighting factor $A_i = +1$.
- A “1 bit“ in the pattern leads to a weighting factor $A_i = -1$.
- All vectors with indices greater than the pattern length are automatically weighted with weighting factor $A_i = 0$.

Multi Code: Whether the channel is to have a multicode characteristic can be selected here. All channels of a base station having this characteristic form a multicode group. For further information see section 8.1.1. If the multicode state is switched on, the corresponding button is shown in cyan to be able to distinguish the channels of a multicode group.

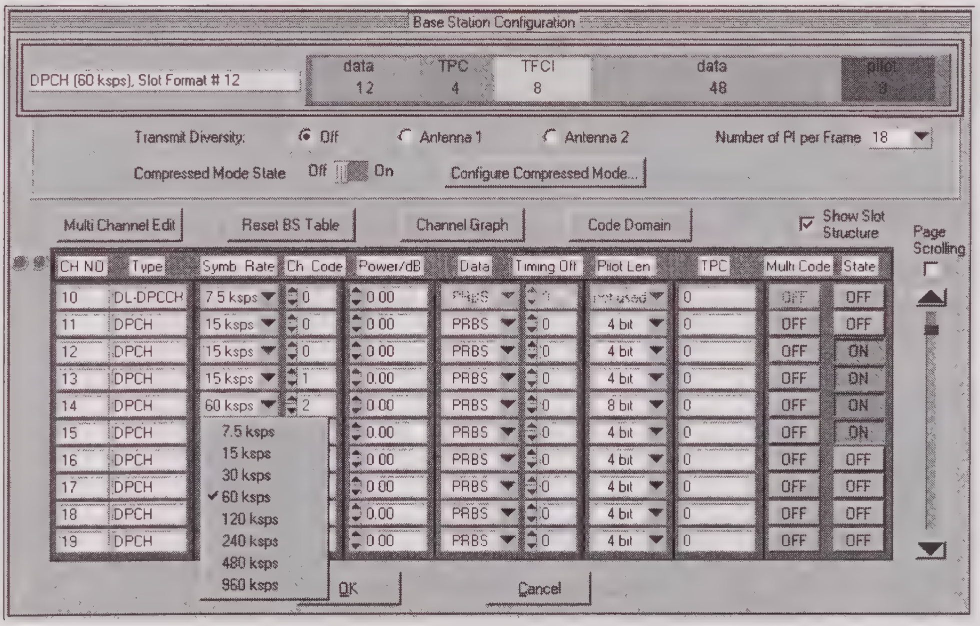
State: This button allows to determine whether the code channel is to be contained in the scenario or not. The State buttons of active channels are shown in green. They thus indicate which channels are active.

The displayed range can be changed with the scrollbar next to the table. The following modes are supported:

Table 8-8 Modes of scrollbar

Function	**Actions required**
Scrolling through the table line by line	- Switch off Page Scrolling ☐ Page Scrolling - Click with the mouse on the large arrows ▲, ▼ or – Mark the black box ■ with the mouse -> scrollbar is activated – Click with the mouse on the large arrows <Up> / <Down>
Scrolling through the table page by page	- Switch on Page Scrolling ☑ Page Scrolling - Click with the mouse on the large arrows ▲, ▼
Jumping to any position in the table	- Click with the mouse on the black box ■ (keep key pressed) – Move to desired position – Release left mouse key

Show Slot Structure
When selecting the option Show Slot Structure, the slot structure of this channel is shown in the upper part of the panel when processing a code channel in the channel table. Effects of the parameter change on the slot structure can be seen there. The graphical slot display disappears automatically if you click the mouse outside the channel table.



DPCH (60 ksps), Slot Format # 12

Transmit Diversity: ● Off ○ Antenna 1 ○ Antenna 2

Number of PI per Frame 18

Compressed Mode State Off On

☑ Show Slot Structure

☐ Page Scrolling

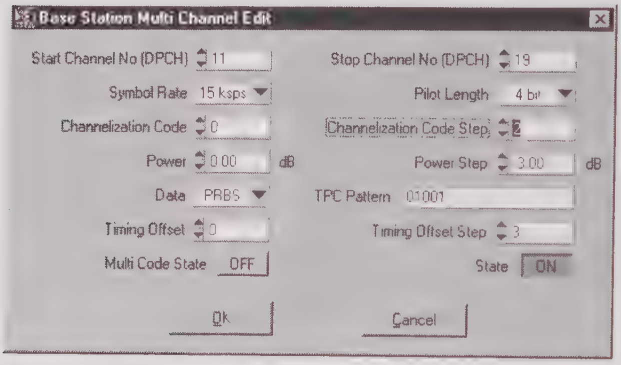
CH NO	Type	Symb Rate	Ch Code	Power/dB	Data	Timing Off	Pilot Len	TPC	Multi Code	State
10	DL-DPCCH	7.5 ksps	0	0.00	PRBS	0	not used	0	OFF	OFF
11	DPCH	15 ksps	0	0.00	PRBS	0	4 bit	0	OFF	OFF
12	DPCH	15 ksps	0	0.00	PRBS	0	4 bit	0	OFF	ON
13	DPCH	15 ksps	1	0.00	PRBS	0	4 bit	0	OFF	ON
14	DPCH	60 ksps	2	0.00	PRBS	0	8 bit	0	OFF	ON
15	DPCH			0.00	PRBS	0	4 bit	0	OFF	ON
16	DPCH			0.00	PRBS	0	4 bit	0	OFF	OFF
17	DPCH			0.00	PRBS	0	4 bit	0	OFF	OFF
18	DPCH			0.00	PRBS	0	4 bit	0	OFF	OFF
19	DPCH			0.00	PRBS	0	4 bit	0	OFF	OFF

Fig. 8-24 Display of slot structure

The slot format number (#) is given in addition to the slot structure. Under the slot format number, you will find a description of the slot structure in [1], Tables 11 and 16.

8.2.2.5.3 Multi Channel Edit

When pressing the Multi Channel Edit button, a window is opened in which several DPCHs can be configured.



Start Channel No (DPCH) 11
Stop Channel No (DPCH) 19
Symbol Rate 15 ksps
Pilot Length 4 bit
Channelization Code 0
Channelization Code Step 2
Power 0.00 dB
Power Step 3.00 dB
Data PRBS
TPC Pattern 01001
Timing Offset 0
Timing Offset Step 3
Multi Code State OFF
State ON

Fig. 8-25 Base Station Multi Channel Edit Panel.

In this window all parameters of the channel table can be set for a group of DPCHs. The value ranges of channel parameters correspond to the associated parameters in the channel table (see above).
Start Channel No (DPCH)/Stop Channel No (DPCH): The range of DPCHs to be set is defined here.

To be able to set entire channel scenarios, start values and stepwidths can be entered for some parameters to set the channel parameters. Parameters **Channelization Code** and **Channelization Code Step** can for example be used to create simple scenarios. Channelization codes with a fixed stepwidth are assigned to the individual code channels. Power profiles (via code axis) can be created in the same way with **Power** and **Power Step**. Parameter **Timing Offset** and **Timing Offset Step** can be used to change the slot timings of the channels and the crest factor of the signal can be influenced (see also section 8.3.3).

8.2.2.5.4 Reset BS Table

The reset button is used to reset the channel table setting of the base station to defined settings. The parameters described in section Common Base Station Settings are not effected. The reset values are shown in the following table.

Table 8-9 Reset values of BS table

Parameter of code channels	Reset value
Symbol rate	15 ksps for all channels
Channelization Code	0 (if permissible) for all channels
Power	0 dB for all channels
Data Source	PRBS for all channels
Timing Offset	0 for all channels
Pilot Length	4 bit
TPC Pattern	„0“ for all channels
Multi Code State	Off for all channels
State	Off for all channels

8.2.2.5.5 Channel Graph

This graph shows all active channels at a glance.

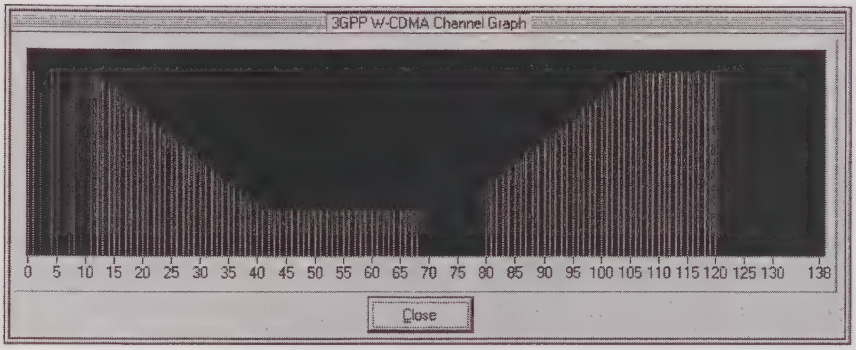


Fig. 8-26 Channel Graph

Special channels (P-CPICH to DL-DPCCH) are marked in red, the DPCHs in green. The channel power can be seen from the length of the line. The channel graph can be indicated at the same time with the other windows. Thus, modifications in the channel table having an effect on the channel graph can be seen immediately.

8.2.2.5.6 Code Domain

The channelization codes are taken from a code tree of hierarchical structure (see below).
The higher the spreading factor, the smaller the symbol rate and vice versa. The product of the spreading factor and symbol rate is constant and always yields the chip rate.
The outer branches of the tree (right-most position in the figure) indicate the channelization codes for the smallest symbol rate (and thus the highest spreading factor). The use of a channelization code of the level with spreading factor N blocks the use of all other channelization codes of levels with spreading factor >N available in the same branch of the code tree. Channelization codes with smaller spreading factor are contained in the codes with larger spreading factor in the same code branch. When using such competitive channelization codes at the same time, the signals of associated code channels are mixed such that they can no longer be separated in the receiver. Orthogonality will then be lost.

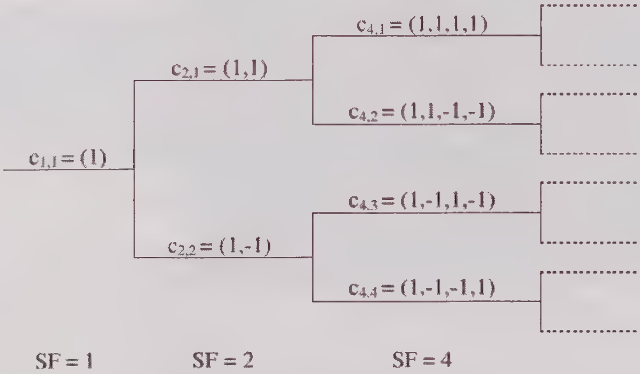


Fig. 8-27 Code tree of channelization codes

The outer branches of the tree (right-most position in the figure) indicate the channelization codes for the smallest symbol rate (and thus the highest spreading factor). The use of a channelization code of the level with spreading factor N blocks the use of all other channelization codes of levels with spreading factor >N available in the same branch of the code tree.
Example: If code $c_{2,1}$ is being used, the remaining branch with $c_{4,1}$ and $c_{4,2}$ is blocked.

The **domain** of a certain channelization code is the outer branch range (with minimum symbol rate and max. spreading factor) which is based on the channelization code selected in the code tree. Using a spreading code means that its entire domain is used.

At a chip rate of 3.84 Mcps, the domain ranges from 0 to 511 ($= \frac{\text{Chip\_rate}}{\text{min.Symbol\_rate}} - 1 = \frac{3.84\text{Mcps}}{7.5\text{ksps}} - 1$)

When pressing the **Code Domain** button, a graphic is opened, showing the assignment of active code channels in the code area.

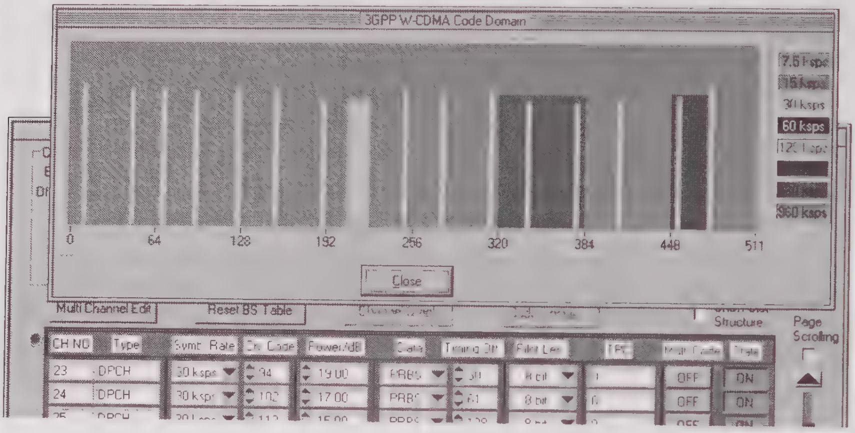


Fig. 8-28 Code domain display

This display shows whether assigned code domains of different channels overlap, i.e. whether a so-called domain conflict occurs. The symbol rates of code channels are characterised by the colour and widths of the corresponding bars. The information at the right of the graph indicates the assignment of colours and symbol rates. The height of the bars corresponds to the power of the individual code channels.
The code domain graph can be indicated at the same time with the other windows. Thus, modifications in the channel table having an effect on the code domain graph can be seen immediately.

If the SF/2 compressed mode is active, the code domain display is split:

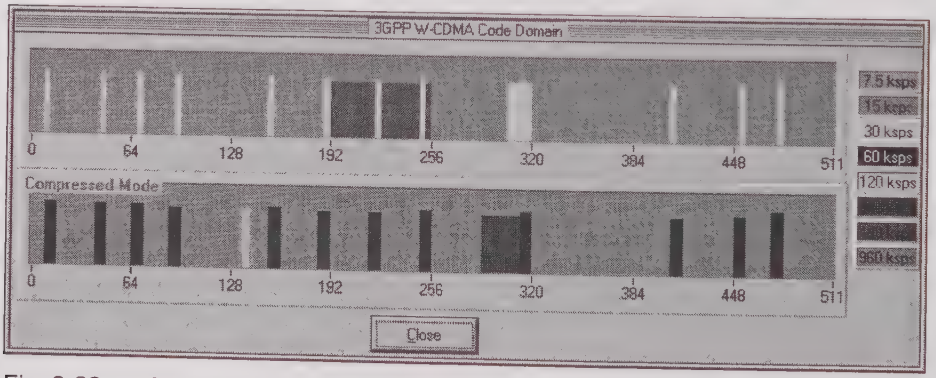


Fig. 8-29 Code domain display in SF/2 compressed mode

The upper half of the display shows the code domain assignment with non-compressed slots, the lower half with compressed slots. It can be recognized clearly that the DPCH bars in the lower half are wider, which is due to the reduction of the spreading factor of these channels. The other channels (e.g. CPICH) have the same width in both halves.

Display of domain conflicts

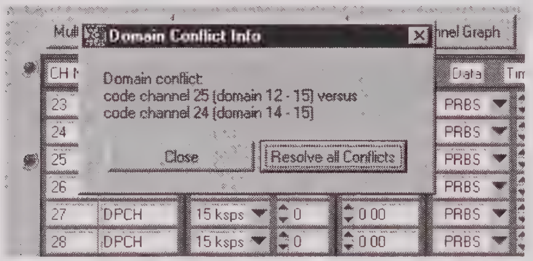
If a domain conflict occurs in the base station, an LED lights up in front of the channel line in the table. All lines in the channel table (lines are processed in ascending channel number order) having a domain conflict with a line of lower index are provided with a red LED ● to the left of the channel number.

A domain conflict occurs when the assigned domains of different channel lines overlap. The assigned code domain of a channel is calculated from the symbol rate of the channel, the minimum possible symbol rate (with 3GPP W-CDMA 7.5 ksps), the chip rate (3.84 Mcps) and the channelization code number with the following equation:

$$\mathbf{Domain\_Factor = \frac{current\_symbol\_rate}{min\_symbol\_rate(= 7.5ksps)}}$$

Lower domain limit = current channelization code number * domain factor
Upper domain limit = lower domain limit + Domain_Factor – 1.

If you click one of the red LEDs, a window is opened comprising accurate information about the domain conflict that occurred. The number of channel lines in the channel table and the assigned domains of the competing channels are displayed.

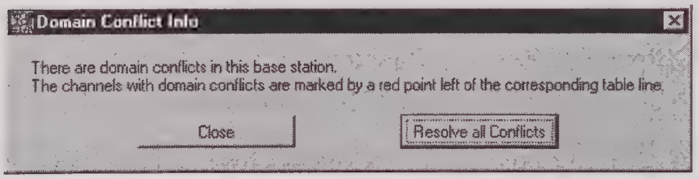


Domain conflict:
code channel 25 (domain 12 - 15) versus
code channel 24 (domain 14 - 15)

Fig. 8-30 Display of domain conflict info

Based on this display you can instruct WinIQSIM to resolve all conflicts. For further information see following text.

In addition to the headline of the channel table, an LED informs on whether domain conflicts occurred in the base station (red LED: ●) or not (green LED: ●). You can also see whether channel lines that are not in the displayed table area cause conflicts. If you click this display with the left mouse key, the following window is displayed:



There are domain conflicts in this base station.
The channels with domain conflicts are marked by a red point left of the corresponding table line.

Fig. 8-31 Domain conflict info

If the SF/2 compressed mode is active, an orange LED appears left of the domain conflict LED if a code domain conflict has occurred in the compressed range.

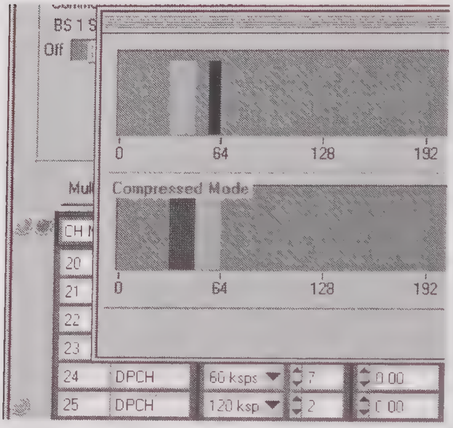
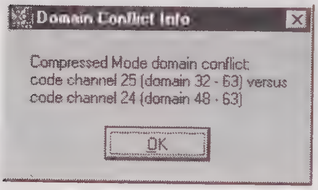


Fig. 8-32 Display of domain conflict in compressed mode

Same as for the other code domain conflicts, information about the conflicting channels is displayed upon clicking the orange LED left of the channel:



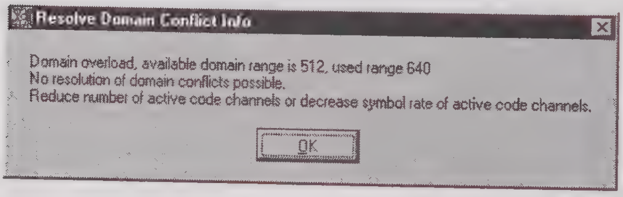
Compressed Mode domain conflict:
code channel 25 (domain 32 - 63) versus
code channel 24 (domain 48 - 63)

Fig. 8-33 Domain conflict info in compressed mode

Resolve all Conflicts

If you select the **Resolve all Conflicts** button in the Domain Conflict Info window, WinIQSIM tries to arrange the active code channels so that no overlapping in the code domain occurs. The channelization code number of the channels varies. The result of a conflict resolution can be seen in the code domain graph.

If the assigned domain of all active channels is higher than the physically available domain (e.g. 5 channels with 960 ksps at a chip rate of 3.84 Mcps), conflicts can no longer be resolved. The following message is displayed. It indicates the number of the assigned and available domain.



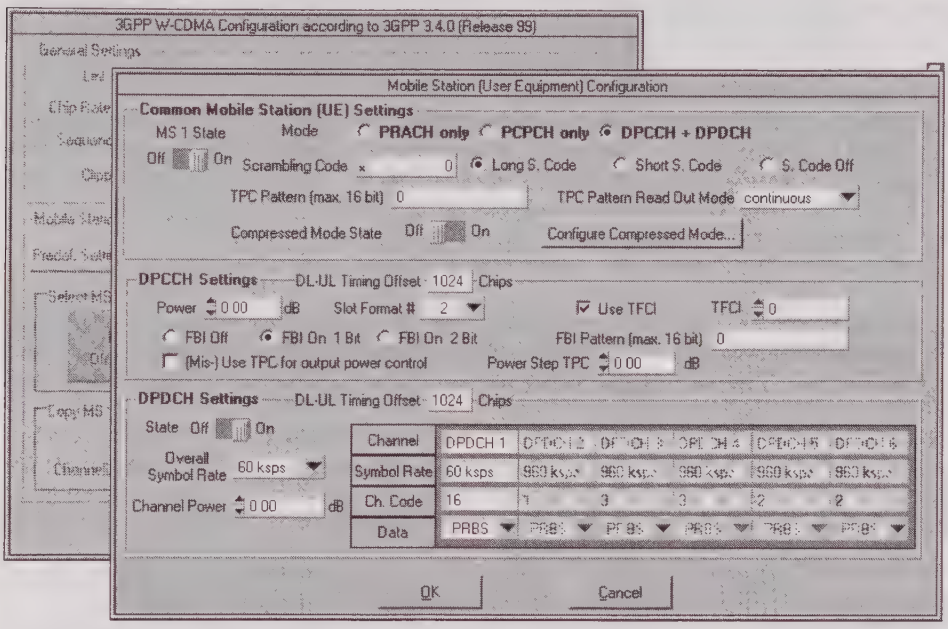
Domain overload, available domain range is 512, used range 640
No resolution of domain conflicts possible.
Reduce number of active code channels or decrease symbol rate of active code channels.

Fig. 8-34 Resolve Domain Conflict Info

You can quit the Base Station Configuration panel by pressing the **OK** button. When the **Cancel** button is pressed, all changed settings are discarded.

8.2.2.6 Mobile Station Configuration

When clicking one of the mobile station blocks in the 3GPP W-CDMA Configuration panel, the Mobile Station Configuration panel is opened. The 3GPP W-CDMA Configuration panel is also displayed but is dimmed since the two windows are interrelated in many ways. The 3GPP W-CDMA configuration parameters can still be read but not changed. As soon as the Mobile Station Configuration panel is closed (OK or Cancel), the 3GPP W-CDMA Configuration panel is enabled again.


3GPP W-CDMA Configuration according to 3GPP 3.4.0 (Release 99)
General Settings
Mobile Station (User Equipment) Configuration
Common Mobile Station (UE) Settings
DPCCH Settings
DPDCH Settings
Configure Compressed Mode...
OK
Cancel

MS 1 State: Off ▮ On

Mode: ○ PRACH only ○ PCPCH only ● DPCCH + DPDCH

Scrambling Code x 0 ● Long S. Code ○ Short S. Code ○ S. Code Off

TPC Pattern (max. 16 bit) 0

TPC Pattern Read Out Mode continuous

Compressed Mode State Off ▮ On

DPCCH Settings — DL-UL Timing Offset 1024 Chips

Power 0.00 dB

Slot Format # 2

☑ Use TFCI

TFCI 0

○ FBI Off ● FBI On 1 Bit ○ FBI On 2 Bit

FBI Pattern (max. 16 bit) 0

☐ (Mis-) Use TPC for output power control

Power Step TPC 0.00 dB

DPDCH Settings — DL-UL Timing Offset 1024 Chips

State Off ▮ On

Overall Symbol Rate 60 ksps

Channel Power 0.00 dB

Channel	DPDCH 1	DPDCH 2	DPDCH 3	DPDCH 4	DPDCH 5	DPDCH 6
Symbol Rate	60 ksps	960 ksps	960 ksps	960 ksps	960 ksps	960 ksps
Ch. Code	16	1	3	3	2	2
Data	PRBS	PRBS	PRBS	PRBS	PRBS	PRBS

Fig. 8-35 Mobile Station Configuration Panel

Due to the extension to 3GPP 3.0.0 the previous operation in the uplink has been modified. In contrast to the 3GPP versions 2.0.0 and 2.1.0 there is no longer a large channel table with 128 DPDCHs. A mobile station now features a maximum of 6 DPDCHs, the parameters of which are specified by the standard to a large extent. To allow for a clearer and easier operation, a distinction is made between 3 modes in uplink (PRACH only, PCPCH only and DPCCH + DPDCH). Only the relevant parameters will then be visible in the mode selected.

8.2.2.6.1 Common Mobile Station Settings

In this area of the panel, parameters that are valid for the entire mobile station can be set.

MS State: The entire mobile station can be switched on or off here.

Mode : The operating mode of the mobile station can be set here. Depending on the mode, the lower part of the panel changes. Only the parameters relevant to the current mode are displayed. The following modes can be selected:

- **PRACH only**: In this mode, the MS generates a single Physical Random Access Channel (PRACH). This channel is required when a call is set up from the mobile to the base station. The specific parameters of the PRACH can be set according to the section **PRACH Settings** (see further down in this section).
- **PCPCH only**: In this mode, the MS generates a single Physical Common Packet Channel (PCPCH). This channel is used for the transmission of packet-oriented services (e.g. SMS). The specific

parameters of the PCPCH can then be set according to the section **PCPCH Settings** (see further down in this chapter).

- **DPCCH + DPDCH**: This is the standard mode of the mobile for speech and data transmission. The MS generates a control channel (DPCCH) and up to 6 data channels (DPDCH). The specific parameters of the PCPCH can then be set in the sections **DPCCH Settings** and **DPDCH Settings** (see further down in this section).

Scrambling Code :
The scrambling code generator (previously called Long Code Generator) is used to scramble the chip sequence as a function of the transmitter. For more information of the structure of the generator and its initialization refer to section 8.1.1.1.
The value range of the scrambling code is 0 to FF FFFF.
A distinction is made between **Long** and **Short Scrambling Code**. The differences between long and short SC can also be found in section 8.1.1.1. The short SC can only be selected in the mode **DPCCH + DPDCH**. For PRACH and PCPCH, the long SC is always used.

The scrambling code generator is deactivated in the setting S.Code ($SC_I = SC_q = 0$).

TPC: You can enter into this field an up to 16-bit long pattern for the Transmitter Power Control field of the DPCCH. One bit is taken from this pattern for each slot and entered in the bit stream several times (depending on the symbol rate). The use of the given bit pattern is determined by the current TPC Pattern Read Out Mode.

TPC Pattern Read Out Mode: The TPC bits are used with W-CDMA to signal to the partner that the transmitter power is increased or reduced. The parameter TPC Pattern Read Out Mode is used to determine how this bit pattern is to be used. A distinction is made between the following modes:

- **Continuous**: A bit is taken from the up to 16-bit long bit pattern for the Transmitter Power Control field of the slots and entered in the bit stream several times (depending on the symbol rate). The given bit pattern is used cyclically.
- **Single + All 0**: A bit is taken from the up to 16-bit long bit pattern for the Transmitter Power Control field of the slots and entered in the bit stream several times (depending on the symbol rate). The bit pattern is used once, then the TPC sequence is continued with 0 bits.
- **Single + All 1**: A bit is taken from the up to 16-bit long bit pattern for the Transmitter Power Control field of the slots and entered in the bit stream several times (depending on the symbol rate). The bit pattern is used once, then the TPC sequence is continued with 1 bit.
- **Single + alt. 01**: A bit is taken from the up to 16-bit long bit pattern for the Transmitter Power Control field of the slots and entered in the bit stream several times (depending on the symbol rate). The bit pattern is used once, then the TPC sequence is continued with 0 and 1 bits alternately (multiplied depending on the symbol rate, i.e. e.g. 00001111).
- **Single + alt. 10**: A bit is taken from the up to 16-bit long bit pattern for the Transmitter Power Control field of the slots and entered in the bit stream several times (depending on the symbol rate). The bit pattern is used once, then the TPC sequence is continued with 1 and 0 bits alternately (multiplied depending on the symbol rate, i.e. e.g.11110000).

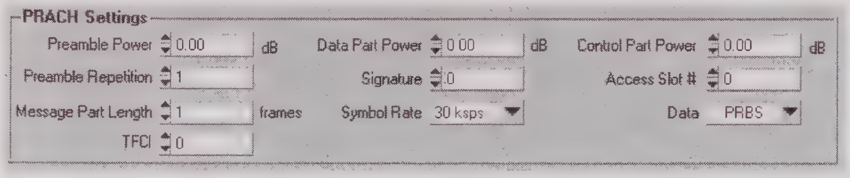
Compressed Mode State : You can define whether the signal is to be simulated in compressed mode (ON) or non-compressed mode (OFF).

Configure Compressed Mode... : This button starts the Compressed Mode Configuration panel. The settings in this panel are described in section **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Note: The "Compressed Mode State" button and the "Configure Compressed Mode..." button are available only in the "DPCCH+DPDCH" mode.

8.2.2.6.2 PRACH Settings

If you select **PRACH only** mode in the section Common Mobile Station Settings, the lower area of the Mobile Station Configuration panel has the following appearance:



PRACH Settings

Preamble Power 0.00 dB
Data Part Power 0.00 dB
Control Part Power 0.00 dB
Preamble Repetition 1
Signature 0
Access Slot # 0
Message Part Length 1 frames
Symbol Rate 30 ksps
Data PRBS
TFCI 0

Fig. 8-36 Mobile Station Configuration panel: PRACH Settings

Preamble Power, Data Part Power, Control Part Power:: These parameters permit to set the powers of the various components of the PRACH. The value range of the power is from –60 dB to 0 dB.

Preamble Repetition: The number of repetitions of the preamble can be set here. Values between 1 and 10 can be selected.

Signature: This field permits to determine the signature to be used for the PRACH. Values between 0 and 15 are possible.

Access Slot#: This parameter permits to shift the starting time of the PRACH. The value range is 0 to 14. (Shifting of the starting time in time slots can be calculated as follows : 2 *Access Slot #).

Note: *The PRACH is sent only once at the beginning of the sequence.*

Message Part Length: Selection of length either as 1 frame or 2 frames.

Symb. Rate: In this column, the symbol rate of the PRACH can be determined. It is possible to select between 15 ksps, 30 ksps, 60 ksps and 120 ksps.

Data: Selection of one of the four data sources Data 0, Data 1, Data 2 or PRBS. The definition of the data sources is described in section 7.2.

TFCI: This field permits to set the value of the TFCI (Transport Format Combination Indicator) field in the control part of the PRACH. The value range of the TFCI is 0 to 1023.

8.2.2.6.3 PCPCH Settings

If you select **PCPCH only** mode in the section Common Mobile Station Settings, the lower part of the Mobile Station Configuration Panel has the following appearance.

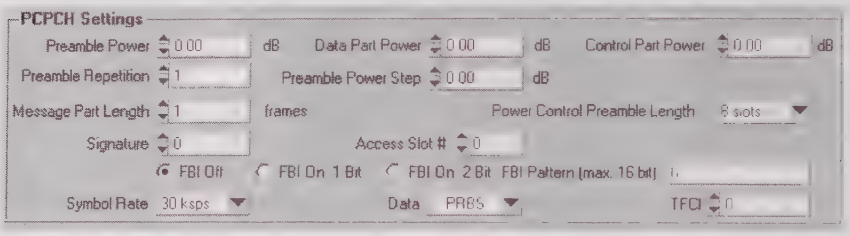

PCPCH Settings
Preamble Power 0.00 dB
Data Part Power 0.00 dB
Control Part Power 0.00 dB
Preamble Repetition 1
Preamble Power Step 0.00 dB
Message Part Length 1 frames
Power Control Preamble Length 8 slots
Signature 0
Access Slot # 0
● FBI Off ○ FBI On 1 Bit ○ FBI On 2 Bit
FBI Pattern (max. 16 bit) 0
Symbol Rate 30 ksps
Data PRBS
TFCI 0

Fig. 8-37 Mobile Station Configuration Panel: PCPCH Settings

Preamble Power, Data Part Power, Control Part Power:: These parameters permit to set the powers of the various components of the PCPCH. The value range of the power is from –60 dB to 0 dB.

Preamble Repetition: The number of repetitions of the preamble can be set here. Values between 1 and 10 are possible.

Preamble Power Step: You can set the power by which the preamble is increased from repetition to repetition. The value range is 0 dB to 10 dB.

Note: *The preamble power that can be entered at the top of the panel is the destination power used in the last repetition of the preamble. If, for example, a preamble power of 0 dB, a repetition of 3 and a power step of 3 dB are set, the following power sequence will be generated:*

Preamble 1 -6 dB	**➔ + 3 dB**	**Preamble 2 -3 dB**	**➔ + 3 dB**	**Preamble 3 0 dB**

Message Part Length : The length of the message part can be determined in frames. Lengths between 1 and 10 frames can be set.

Signature: This field permits to determine the signature to be used for the PCPCH. Values between 0 and 15 can be set.

Access Slot#: This parameter permits the starting point of the PCPCH to be shifted. The value range is 0 to 14. (Shifting of the starting point in time slots is calculated as follows: 2 *Access Slot #).

Note: *The PCPCH is only sent once at the beginning of the sequence.*

Message Part Length: select length as 1 frame or 2 frames.

FBI Off / FBI On 1 Bit / FBI On 2 Bit: 3GPP provides optional bits for transmission of feedback information. The desired length of this bit field can be set here.

FBI Pattern: In this field, an up to 16-bit long pattern can be entered for the FBI field in the control part (of the message part) of the PCPCH. The given bit pattern is used cyclically.

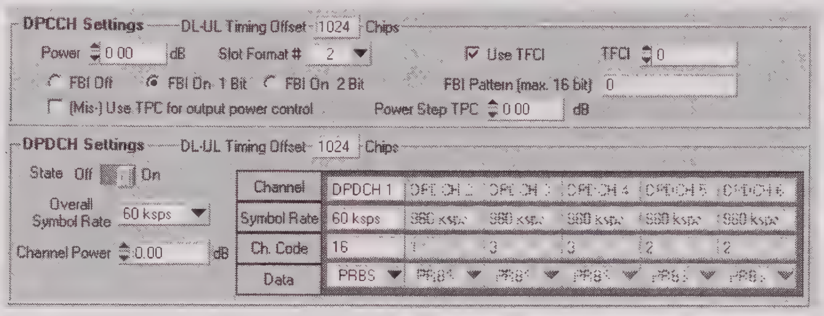
Symb. Rate: In this column, you can define the symbol rate of the PCPCH. All symbol rates between 15 ksps and 960 ksps are available.

Data: Selection of one of the four data sources Data 0, Data 1, Data 2 or PRBS. The definition of data sources is to be found in 7.2.

TFCI: Here, you can set the value of the TFCI (Transport Format Combination Indicator) field in the control part of the PCPCH. The value range of the TFCI is 0 to 1023.

8.2.2.6.4 DPCCH and DPDCH Settings

If you select **DPCCH + DPDCH** mode in the section Common Mobile Station Settings, the lower part of the Mobile Station Configuration Panel has the following appearance.



DPCCH Settings DL-UL Timing Offset 1024 Chips

Power 0.00 dB Slot Format # 2 ☑ Use TFCI TFCI 0

○ FBI Off ● FBI On 1 Bit ○ FBI On 2 Bit FBI Pattern (max. 16 bit) 0

☐ (Mis-) Use TPC for output power control Power Step TPC 0.00 dB

DPDCH Settings DL-UL Timing Offset 1024 Chips

State Off On

Overall Symbol Rate 60 ksps

Channel Power 0.00 dB

Channel	DPDCH 1	DPDCH 2	DPDCH 3	DPDCH 4	DPDCH 5	DPDCH 6
Symbol Rate	60 ksps	960 ksps	960 ksps	960 ksps	960 ksps	960 ksps
Ch. Code	16	1	3	3	2	2
Data	PRBS	PRBS	PRBS	PRBS	PRBS	PRBS

Fig. 8-38 Mobile Station Configuration panel: DPCCH + DPDCH settings

In this mode, one DPCCH and up to 6 DPDCHs are always generated.

8.2.2.6.4.1 DPCCH Settings

Note: *When an uplink signal is generated (DPCCH+DPDCH mode), the downlink-uplink timing offset of 1024 chips is taken into account automatically. The uplink signal is calculated so that it is in synchronism with the downlink reference timing, i.e. the first uplink frame starts at chip position 1024 of the simulated signal.*

Power/dB: The power of the DPCCH can be set here. The value range of the channel power is from -60 dB to 0 dB.

Slot Format # : WinIQSIM offers two ways of selecting the desired DPCCH slot format:

1. Selection of slot format number as specified in [1], Table 2.
   Use of the TFCI information ("Use TFCI") is activated/deactivated and the FBI bit length is adapted automatically.
2. Activate/deactivate the "Use TFCI" switch and select the FBI bit length.
   The resulting slot format is indicated.

Use TFCI: You can decide here whether the DPDCH should use the information of the TFCI field. If this option is activated, the TFCI field is enabled.

TFCI: The TFCI (Transport Format Combination Indicator) field contains information on the symbol rate combinations used in the DPDCHs. The value range of the TFCI is 0 to 63.

FBI Off / FBI On 1 Bit / FBI On 2 Bit: 3GPP optionally provides bits for the transmission of feedback information. Select the desired length of the bit field here.

FBI Pattern: This field permits to enter an up to 16-bit long pattern for the FBI field in the DPCCH. The specified bit pattern is used cyclically.

(Mis-)Use TPC for output power control / Power Step : If this field is marked, the pattern is misused in order to vary the transmitter power versus time. A bit is taken from this pattern for each slot in order to increase (Bit = "1") or reduce (Bit = "0") the channel power. The upper limit is 0 dB and the lower limit is -60 dB.

Note: *Note that the DPDCHs are always controlled together with the DPCCH in the output power. The starting power of DPDCH and DPCCH may be different, however the power change is the same.*

8.2.2.6.4.2 DPDCH Settings

State: All DPDCHs can be completely switched on or off here.
Overall Symbol Rate: The overall data rate of all uplink DPDCHs can be determined here. The structure of the DPDCH table depends on this parameter. The overall symbol rate indicates the active DPDCHs, their symbol rate and the channelization codes used (see table further down).

Channel Power: You can set the power of the active DPDCHs here. Each active DPDCH features this channel power. The power of the active channels cannot be configured independently (this also complies with the definition of 3GPP).

Table 8-10 Structure of the DPDCH channel table depending on the overall symbol rate

Overall symbol rate	DPDCH 1	DPDCH 2	DPDCH 3	DPDCH 4	DPDCH 5	DPDCH 6
15 k	State: ON S-Rate: 15 k Ch. Code: 64	State: OFF	State: OFF	State: OFF	State: OFF	State: OFF
30 k	State: ON S-Rate: 30 k Ch. Code: 32	State: OFF	State: OFF	State: OFF	State: OFF	State: OFF
60 k	State: ON S-Rate: 60 k Ch. Code: 16	State: OFF	State: OFF	State: OFF	State: OFF	State: OFF
120 k	State: ON S-Rate: 120 k Ch. Code: 8	State: OFF	State: OFF	State: OFF	State: OFF	State: OFF
240 k	State: ON S-Rate: 240 k Ch. Code: 4	State: OFF	State: OFF	State: OFF	State: OFF	State: OFF
480 k	State: ON S-Rate: 480 k Ch. Code: 2	State: OFF	State: OFF	State: OFF	State: OFF	State: OFF
960 k	State: ON S-Rate: 960 k Ch. Code: 1	State: OFF	State: OFF	State: OFF	State: OFF	State: OFF
2 x 960 k	State: ON S-Rate: 960 k Ch. Code: 1	State: ON S-Rate: 960 k Ch. Code: 1	State: OFF	State: OFF	State: OFF	State: OFF
3 x 960 k	State: ON S-Rate: 960 k Ch. Code: 1	State: ON S-Rate: 960 k Ch. Code: 1	State: ON S-Rate: 960 k Ch. Code: 3	State: OFF	State: OFF	State: OFF
4 x 960 k	State: ON S-Rate: 960 k Ch. Code: 1	State: ON S-Rate: 960 k Ch. Code: 1	State: ON S-Rate: 960 k Ch. Code: 3	State: ON S-Rate: 960 k Ch. Code: 3	State: OFF	State: OFF
5 x 960 k	State: ON S-Rate: 960 k Ch. Code: 1	State: ON S-Rate: 960 k Ch. Code: 1	State: ON S-Rate: 960 k Ch. Code: 3	State: ON S-Rate: 960 k Ch. Code: 3	State: ON S-Rate: 960 k Ch. Code: 2	State: OFF
6 x 960 k	State: ON S-Rate: 960 k Ch. Code: 1	State: ON S-Rate: 960 k Ch. Code: 1	State: ON S-Rate: 960 k Ch. Code: 3	State: ON S-Rate: 960 k Ch. Code: 3	State: ON S-Rate: 960 k Ch. Code: 2	State: ON S-Rate: 960 k Ch. Code: 2

Note: *With an overall rate smaller than 960 ksps only DPDCH1 is active, its rate is equal to the overall rate and the channelization code is equal to spreading factor/4 (spreading factor = chip rate / symbol rate). With an overall rate greater than 960 k, all active DPDCHs have the rate 960 ksps.*

POWER Power of each DPDCH (they all have the same power)
Range: -60 to 0 dB

Channel table of the DPDCHs:

Symbol Rate: The symbol rate of the DPDCH is displayed. This parameter cannot be changed. Its value depends on the overall symbol rate.

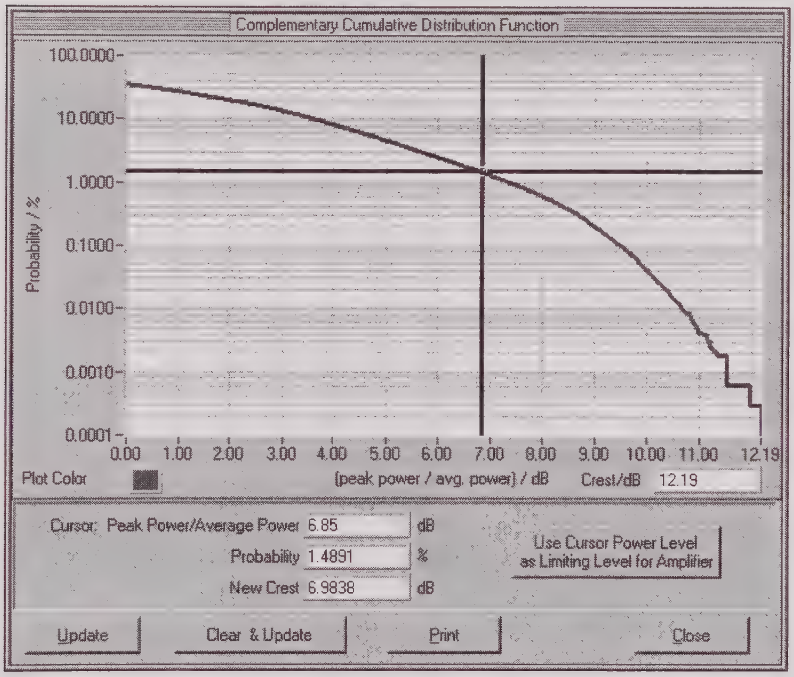
Channelization Code: The channelization code of the DPDCH is displayed. This parameter cannot be changed. Its value depends on the overall symbol rate.

Data: Selection of one of the four data sources Data 0, Data 1, Data 2 or PRBS.
For the definition of the data sources see 7.2.

8.2.2.7 CCDF Test

A complementary cumulative distribution function can be generated from the filtered I/Q samples. This function gives the probability of the magnitude of complex samples exceeding a predefined threshold.

If this threshold is interpreted as the radius of a circle centered on the origin, the radius is plotted along the horizontal axis and the probability of the samples lying outside this circle along the vertical axis.



Crest/dB 12.19

Cursor: Peak Power/Average Power 6.85 dB
Probability 1.4891 %
New Crest 6.9838 dB

Fig. 8-39 CCDF function

Only radii corresponding at least to the average power will be considered.

Crest factor
The crest factor is displayed in the lower part of the panel. This value can additionally be output at any position in the diagram by moving the mouse to the required position and pressing the left mouse key.

Use Cursor Power Level as Limiting Level for Amplifier
W-CDMA signals often have high crest factors. In most of the cases, only a small part of signal values with a high level will lead to a high crest factor. That is why level limitations are mostly used in real W-CDMA systems. Such a level limitation is also possible by means of the amplifier block (see section 5.12) in WinIQSM.
A trace point can be selected in the CCDF display by means of the cursor. The values Peak Power/Average Power and Probability assigned to the cursor position are displayed in the section below the trace. With the signal level limited (soft limited amplifier) the expected crest factor for a level selected with the cursor is indicated in the New Crest field.

When pressing the **Use Cursor Power Level as Limiting Level for Amplifier** button, the selected cursor level is copied as a limitation level to the amplifier block and this block is activated. A level limitation can thus be very easily triggered from the CCDF trace. This form of limitation (after baseband filtering) impairs the signal spectrum to a large extent. For a remedy see section 8.3.3.

Note: *A far better method of limiting the crest factor is to use **Clipping** (Parameter **Clipping Level**) implemented in all (W-) CDMA systems of WinIQSIM (see also section 8.2.2.8).*

Display of several traces in a diagram

WinIQSIM supports the plotting of several CCDF functions into a diagram. It is thus very easy to check the effect of a parameter on the distribution function.
Proceed as follows:

1. Get the CCDF displayed for the first signal and mark the trace with the value of the crest factor.
2. Change the parameters of the signal **without** closing the CCDF display.
3. Change back to the CCDF panel and select a new colour.
4. Press the Update button. The signal will now be recalculated and the new CCDF trace is displayed.
5. Mark the new trace with the new crest factor (left mouse key).
6. Repeat steps 2 to 5 until all traces are plotted.

Plotting of the traces will be completed when the panel is closed or the Clear & Update button is pressed.

8.2.2.8 Effect of the Parameter CLIPPING LEVEL on the Signal

W-CDMA signals may have very high crest factors particularly with many channels and unfavourable data offsets (see section 8.3.2 and 8.3.3). High crest factors entail two basic problems:

1. The nonlinearity of the power amplifier (compression) causes intermodulation which expands the spectrum (spectral regrowth).
2. Since the level in the D/A converter is relative to the maximum value, the average value is converted with a relatively low resolution. This results in a high quantization noise.

Both effects increase the adjacent-channel power.

From all the possibilities listed in section 8.3.3 for influencing the crest factor, changing the CLIPPING LEVEL is the simplest and most effective. In this case a limit value is defined which is a percentage of the highest peak value.
All current values exceeding this limit will be clipped to this value. Since clipping is done prior to filtering, the procedure does not influence the spectrum. The EVM however increases.

Since clipping the signal not only changes the peak value but also the average value, the effect on the crest factor is unpredictable. The following table shows the effect of the CLIPPING LEVEL on the crest factor for typical scenarios.

Table 8-11 Change of crest factor in the case of clipping

CLIPPING LEVEL	**Crest factor with scenario**			
	Downlink : 10 DPCHs "minimum crest" 30 ksps	**Downlink : 10 DPCHs "worst crest" 30 ksps**	**Downlink : 10 DPCHs "average crest" 30 ksps**	**Downlink : 128 DPCHs "average crest" 30 ksps**
100%	9.89 dB	14.7 dB	10.9 dB	21.7 dB
80%	8.86 dB	12.9 dB	9.39 dB	20.2 dB
50%	7.50 dB	10.1 dB	8.29 dB	16.9 dB
20%	5.50 dB	6.47 dB	6.23 dB	12.5 dB
10%	5.34 dB	6.06 dB	5.80 dB	9.57 dB
5%	5.34 dB	6.06 dB	5.80 dB	8.17 dB

Effect of clipping on the constellation shown by way of a 4-DPCH configuration:

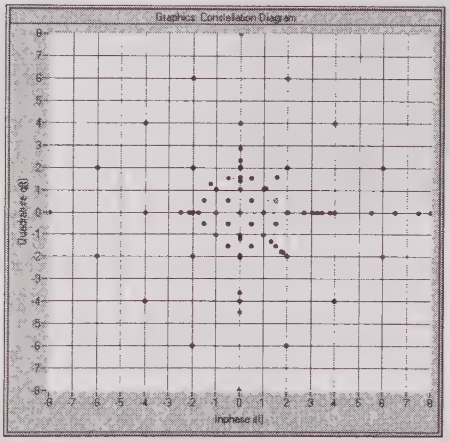


Fig. 8-40 Constellation at clipping level 100% (not clipped)

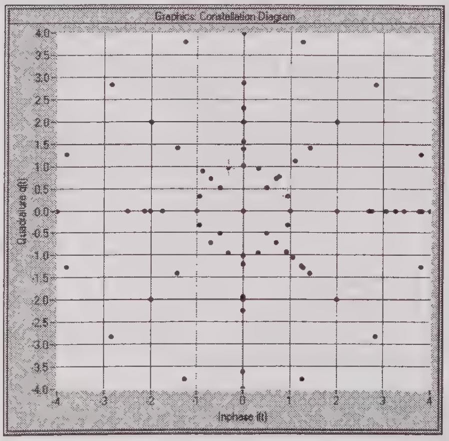
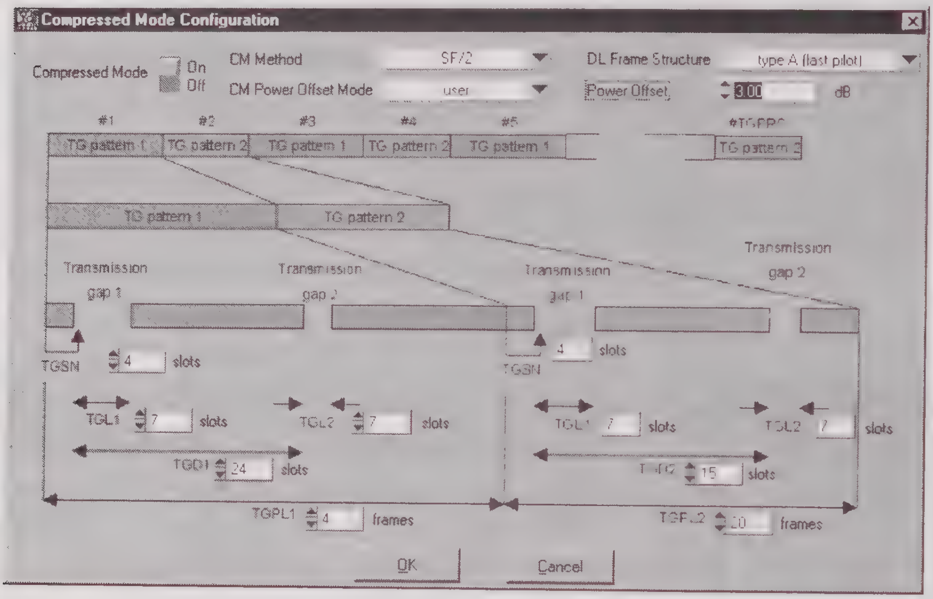


Fig. 8-41 Constellation at clipping level 50%

8.2.2.9 Compressed Mode Configuration Panel

In this panel, all compressed mode parameters can be set. Since the parameters are practically identical for the uplink and the downlink, the description given below applies to both directions of transmission. Any differences are described at the relevant points.


Compressed Mode Configuration

Compressed Mode ○ On ● Off

CM Method: SF/2

CM Power Offset Mode: user

DL Frame Structure: type A (last pilot)

Power Offset: 3.00 dB

TGSN: 4 slots

TGL1: 7 slots

TGL2: 7 slots

TGD1: 24 slots

TGPL1: 4 frames

TGSN: 4 slots

TGL1: 7 slots

TGL2: 7 slots

TGD2: 15 slots

TGPL2: 20 frames

Fig. 8-42 Compressed Mode Configuration panel

Note: *The following parameter are describet in section 8.1.2.*

Compressed Mode: Switch the compressed mode on or off.

CM Method: Select the compressed mode method:

CM method	**Available in downlink**	**Available in uplink**	**Use of power offset**	**Format of compressed slots in downlink**	**Format of compressed slots in uplink**
Higher layer scheduling	**YES**	**YES**	**NO**	**Format A**	**Format A / B**[1]
SF/2	**YES**	**NO**	**YES**	**Format B**	**---**
Puncturing	**YES**	**YES**	**YES**	**Format A**	**Format A / B**[1]

DL Frame Structure: Select type B (first TPC, last pilot) if the first TPC field is to be sent in the transmission gap. Otherwise, select type A (last pilot). This option is available only in the downlink.

CM Power Offset Mode: The compressed slots can be sent with a power offset, i.e. at an increased power level. In the "auto (by pilot bit ratio)" mode, the power offset is obtained as follows:

$$\frac{Number\ of\ \ pilot\ bits\ of\ \ non-compressed\ slots}{Number\ of\ \ pilot\ bits\ of\ \ compressed\ slots}$$

Example: A DPCCH with slot format #2 is set in the uplink. The transmission gap has a length of seven slots and comes within one frame.

---

[1] . The slot format is set depending on the number of active slots of a frame.

The frame, therefore, contains eight active slots, which means that slot format #2B is used (see footnote [1] to Table 2).
The power offset in this case is 5/3 = 4.44 dB.
In the "user" mode, the power offset can be defined manually.

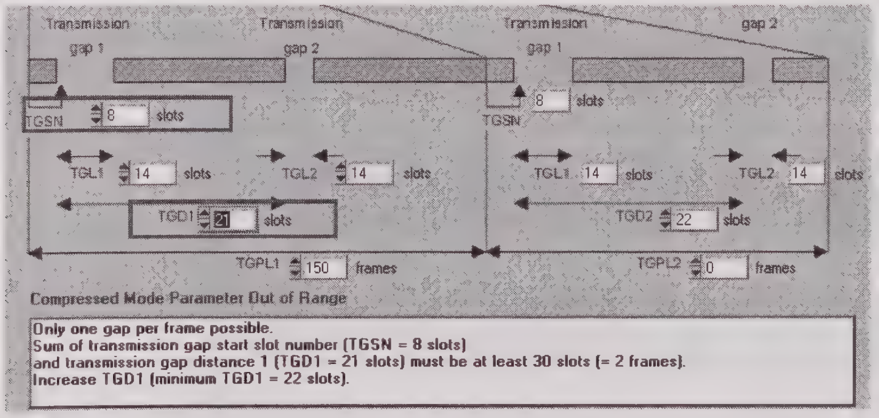
Power Offset: Set the power offset value, if "user" has been selected as the CM Power Offset Mode.

The remaining parameters displayed in this panel denote the position of the transmission gaps. The meaning of the abbreviations is explained in section 8.1.2.
For one, the values of these parameters must be within certain limits, which are listed in the table below.

Parameter	Minimum value	Maximum value
TGSN	0	14
TGL1	3	14
TGD1	3	100
TGL2	3	14
TGPL1	1	150
TGD2	3	100
TGPL2	0 (i.e. pattern 2 is not used)	150

For another, these parameters are interrelated in many ways. For example, the transmission gap distance must be selected so that no frame contains more than one gap.
In the event of conflicting settings,

- the conflicting parameters are highlighted by a red frame,
- an error message is output,
- an alternative is proposed to solve the conflict.



TGSN 8 slots
TGL1 14 slots
TGL2 14 slots
TGD1 21 slots
TGPL1 150 frames
TGSN 8 slots
TGL1 14 slots
TGL2 14 slots
TGD2 22 slots
TGPL2 0 frames

Compressed Mode Parameter Out of Range

Only one gap per frame possible.
Sum of transmission gap start slot number (TGSN = 8 slots)
and transmission gap distance 1 (TGD1 = 21 slots) must be at least 30 slots (= 2 frames).
Increase TGD1 (minimum TGD1 = 22 slots).

Fig. 8-43 Response in the event of conflicting settings in Compressed Mode Configuration panel

8.3 Background Information for the Generation of 3GPP W-CDMA Signals

This section provides some background information on W-CDMA signals to support the user in generating signals with certain characteristics.

8.3.1 3GPP W-CDMA Signals in Time and Frequency Domain

8.3.1.1 Time Domain

8.3.1.1.1 Downlink

The two spreading methods for SCHs and the remaining (downlink) channel types are explained for the channels P-CCPCH, P-SCH and S-SCH. (These three channels were referred to as "Perch" in previous versions of the W-CDMA standard and WinIQSIM)

A (downlink) signal containing the following components is generated:

- P-CCPCH (-20 dB)
- P-SCH (-14 dB)
- S-SCH (-14 dB)

The SCH components are generated with double amplitude for better distinction against PCCPCH.

Sequence length = 1
Filtering: root cosine (roll off = 0.22), impulse length = 32, oversampling = 8
Data source: PRBS23
No superimposed impairments active

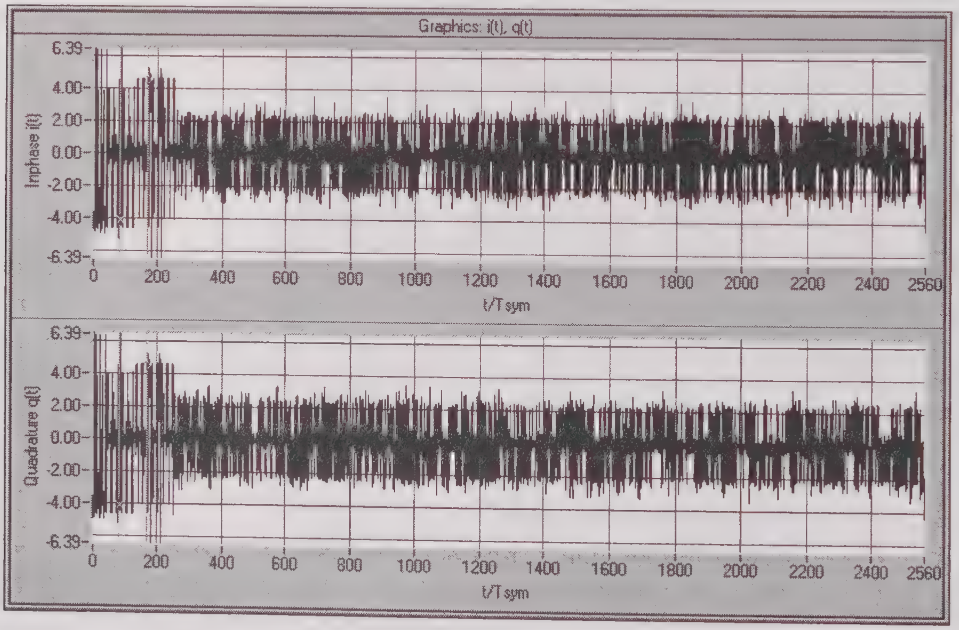


Fig. 8-44 Signal consisting of P-CCPCH, P-SCH and S-SCH in time domain

First you can see that a time slot consists of 2560 chips. You will also notice that the power is higher with the first 10% of the signal. This is the SCH. Zooming in on this transition point reveals the following:

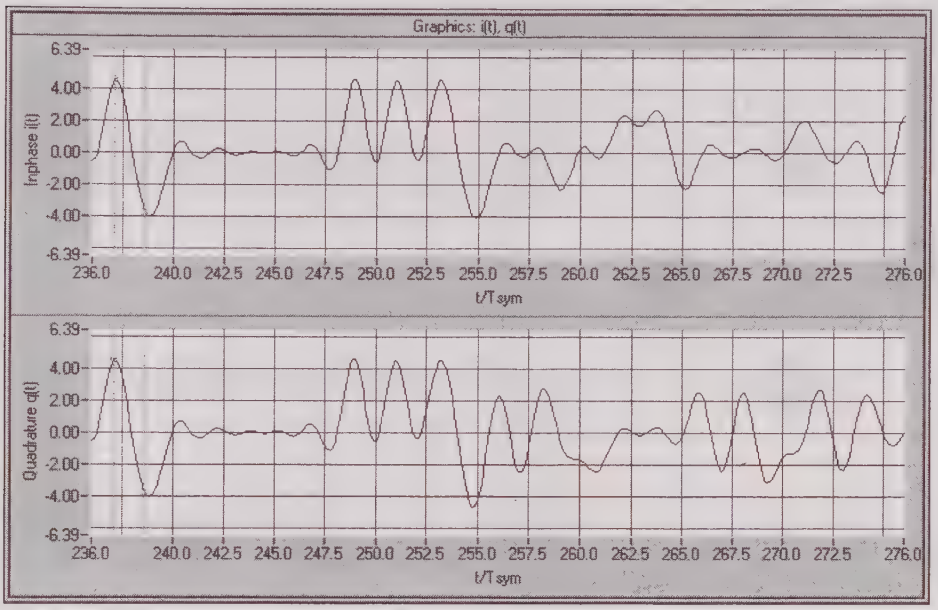


Fig. 8-45 Signal consisting of P-CCPCH, P-SCH and S-SCH in time domain (zoomed)

The right section (i.e. the 9 PCCPCH symbols) is spread as described in Fig. 8-1. You can see that for each symbol clock one of the two components is 0 and the other one ±2 (a certain inaccuracy results from the root cosine filter used).

This is the standard spreading scheme as it is also used for S-CCPCH, DPCH and all other downlink channel types.

The left section (the synchronisation code symbol occupying the chip range 0 to 255) is obtained using special synchronisation code spreading: There is no scrambling unit ($S_i = C_i$, $S_q = C_q$).
Since the synchronisation code symbol is defined as 11, the following is always true:

$$S_i = S_q.$$

The result is a BPSK mapping turned by 45° relative to the QPSK constellation of the S-CCPCH component.

Since the synchronisation code symbol is sent twice (in the primary and secondary SCH) with different spreading, the signal power is doubled in this range.

The constellation diagram of the perch channel, therefore, has the following appearance:

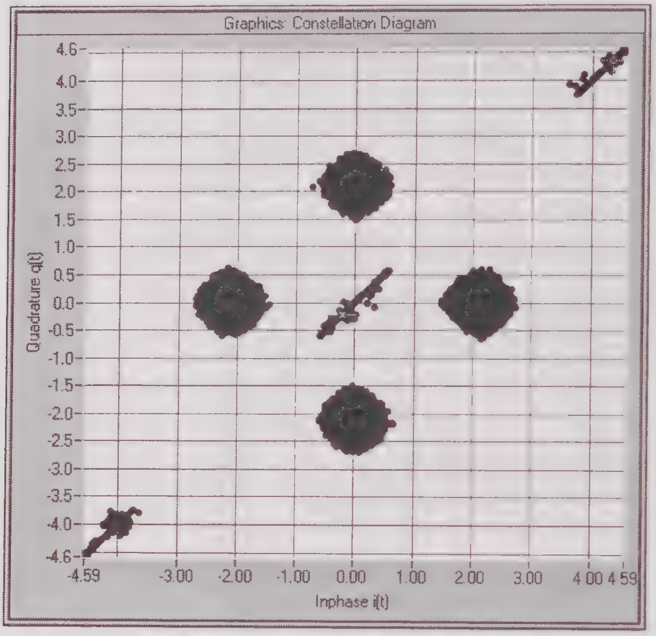


Fig. 8-46 Constellation diagram of a signal consisting of P-CCPCH, P-SCH and S-SCH

The four circular areas are due to P-CCPCH ("QPSK"), the linear areas (diagonals) to SCH ("BPSK").

The spreading/constellation diagram of P-CPICH, S-CPICH, S-CCPCH, PICH, AP-AICH, CD-AICH, PDSCH, DL-DPCCH and DPCH are identical to the spreading/constellation diagram of P-CCPCH.

Envelopes

The following figures are based on a power of 0 dB.
To eliminate smearing of the amplitude due to the root cosine filter, all envelopes are calculated using a square-wave filter.

The channels P-CPICH, S-CPICH, S-CCPCH, PICH, PDSCH feature a constant envelope during the complete sequence.

Note: *Section 8.2.2.5.1, "Misuse TPC for output power control", describes how the envelope of e.g. DPCHs can be varied.*

The P-CCPCH is blanked during the first 256 chips of the slot.

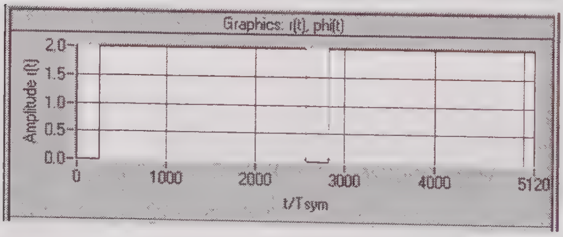


Fig. 8-47 Envelope of P-CCPCH

P-SCH and S-SCH are active during the first 256 chips only:

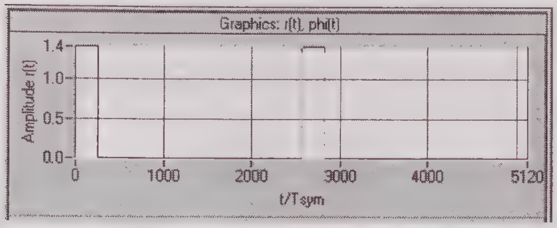


Fig. 8-48 Envelope of P-SCH or S_SCH

AP-AICH and AICH are transmitted only during the first 4096 chips of the signal.

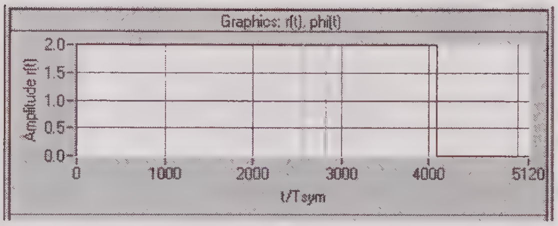


Fig. 8-49 Envelope of AICH (subchannel)

AP-AICH and AICH consist of up to 16 superimposed single channels that are modulated with different orthogonal vectors. In some sections, cancellations or excessive levels may result. The following diagram shows the signal with the input pattern "1010" :

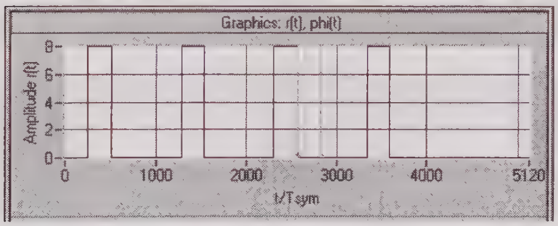


Fig. 8-50 Envelope of AICH (four subchannels)

The DL-DPCCH is used during transmission of the PCPCH to readjust the output power of the mobile. Since there is no data transfer to the mobile in this phase, the DL-DPCCH is based on a DPCH (7.5 ksps without TFCI), the data fields of which are blanked ("DTX"):

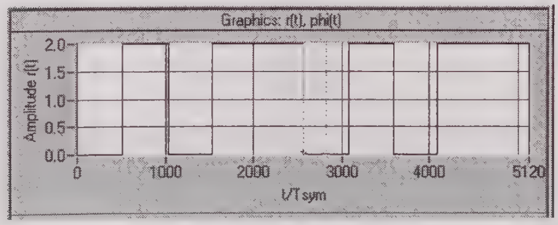


Fig. 8-51 Envelope of DL-DPCCH

At first, DPCHs are permanently active, however the TFCI fields are blanked at high data rates (>= 60 ksps) if no TFCI information is transferred ("DTX"). A 60-ksps channel, for example, then has the following appearance:

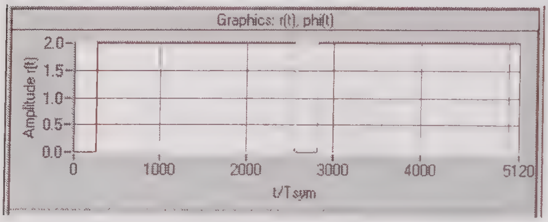


Fig. 8-52 Envelope of DPCH 60 ksps without TFCI

8.3.1.1.2 Uplink

In the "DPCCH+DPDCH" mode, the signal consists of a DPCCH and none, one or several (max. 6) DPDCHs.

To derive the constellation of this signal, the constellation of a single channel (DPDCH or DPCCH) is considered first. Its data are exclusively supplied to the I or Q path. The second path is not used (second path is: $C_q = 0$).

with

$$S_i = C_i SC_i - C_q SC_q'$$
$$S_q = C_i SC_q' + C_q SC_i$$

the following equation is obtained:

$$S_i = C_i SC_i$$
$$S_q = C_i SC_q'$$

This corresponds to a QPSK constellation diagram. Compared to the DPCH constellation diagram, this diagram is shifted and the constellation points only have half the amplitude:

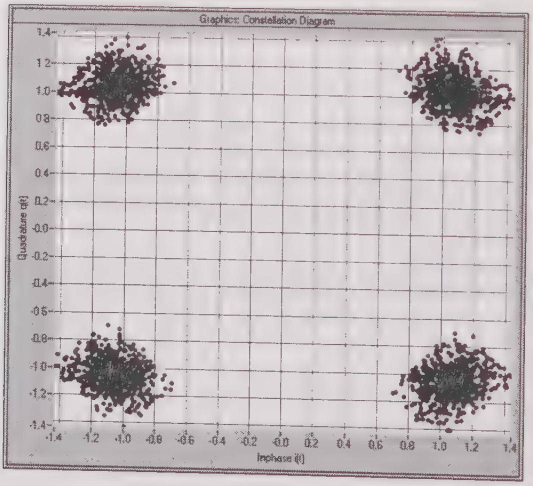


Fig. 8-53 Constellation of a DPDCH/DPCCH channel

Note: *A suitable modification of the PN sequences ("HPSK") in the uplink eliminates 50 % of all zero-crossings, which, in contrast to the downlink, causes a deformation of the constellation ranges.*

If DPCCH and DPDCH are combined, the constellation considerably depends on the ratio of the channel powers. If the two powers are equal, a constellation as with the P-CCPCH will be obtained. The following illustration shows the constellation with DPCCH power 0 dB and DPDCH power –6 dB:

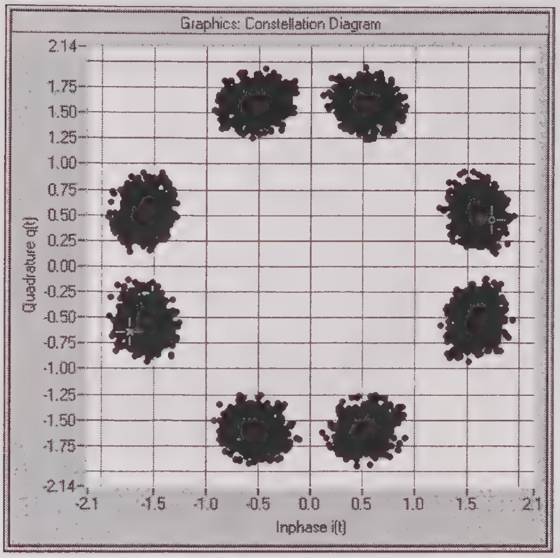


Fig. 8-54 Constellation of an uplink signal consisting of a DPDCH and a DPCCH

PRACH and PCPCH consist of preambles and the message part. Similar to a P-CCPCH, the preamble uses the 4 constellation points (2, 0), (0,2), (-2, 0) and (0, -2). In the case of the message part, separate powers can set for Data (on the I path) and Control (on the Q path) so that a component is obtained as described above for the DPCCH+DPDCH signal.
As the third part of the constellation, points can be seen in the origin, which can be assigned to the interval between preamble and message part:

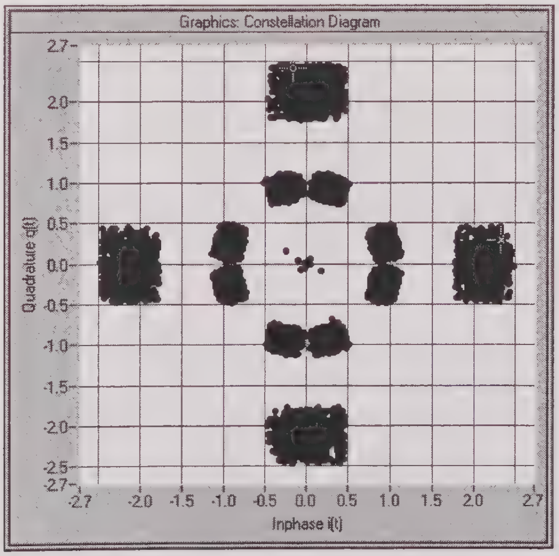


Fig. 8-55 Constellation of a PRACH

Envelopes

To eliminate smearing of the amplitude due to the root-cosine filter, all envelopes are calculated using a square-wave filter.

The DPCCH and the DPDCHs are continuous channels that feature a constant envelope during the complete sequence.

Note: *Section 8.2.2.6, "Misuse TPC for output power control", describes how to vary also the envelope of DPCCH and DPDCHs.*

PRACH and PCPCH consist of one or several preambles and the message part.

Example of a PRACH with a preamble and reduced power in the message part:

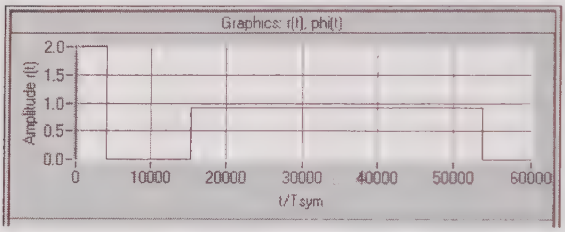


Fig. 8-56 Envelope of a PRACH

Example of a PCPCH with the parameters

- Access Slot # = 0
- Preamble Repetition = 4
- Preamble Power Step = 1 dB
- Message Part Length = 1 frame
- Preamble Power = 0 dB
- Control Part Power = 0 dB
- Data Part Power = 0 dB

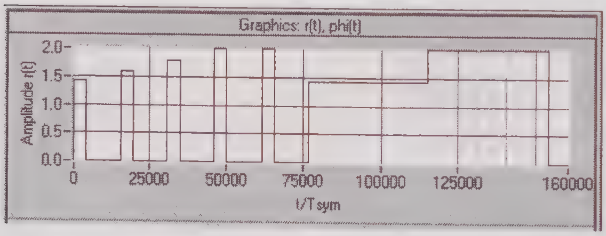


Fig. 8-57 Envelope of a PCPCH

8.3.1.2 Frequency Range

The spectrum of a 3GPP W-CDMA signal (a DPCH channel) corresponds to that of a QPSK signal with identical filter parameters.

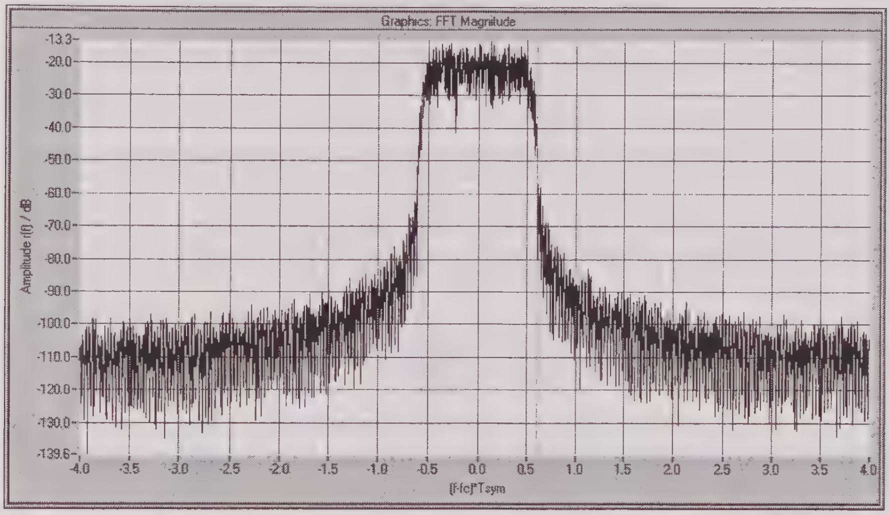


Fig. 8-58 Magnitude spectrum of a 3GPP W-CDMA signal

If signals with several channels are investigated, a certain ripple may occur in the range +/-0.5 of the chip rate.

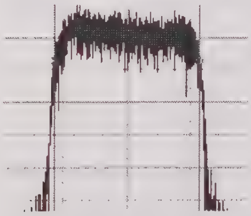


Fig. 8-59 Magnitude spectrum (section) of a 3GPP W-CDMA signal with several channels

This effect can be influenced by the choice of the channelization codes and is reduced with increasing period of observation, i.e. higher averaging for the FFT settings.

8.3.2 Effect of Data Source on the 3GPP W-CDMA Signal

The choice of the data sources is of vital importance for the signal characteristics. Especially the constellation diagram and the crest factor can be modelled to a large extent by an appropriate data selection.

Since the number of channels can be very high, particularly in the downlink, this section deals only with the simulation of downlink signals.
In the following it is assumed that all channels are generated with the same scrambling code sequences and equal channel powers of 0.0 dB.
A symbol rate of 60 ksps is selected.

8.3.2.1 Two DPCHs with Uncorrelated Data

If the two channels are uncorrelated (data source PRBS with active option ☑ Different start values for PRBS), the resulting constellation diagram is obtained from the superposition of the constellations of two separate signals (see Fig. 8-6 Constellation diagram of a 3GPP W-CDMA signal with two DPCH channels).

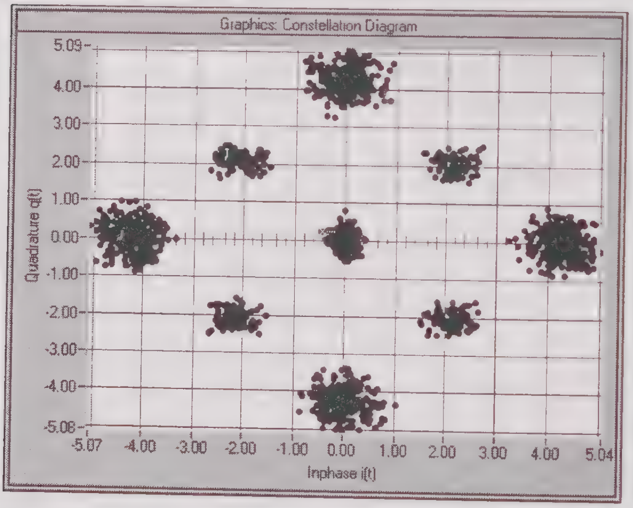


Fig. 8-60 Constellation of a signal with two DPCHs (uncorrelated data)

The resulting crest factor is 8.07 dB.

8.3.2.2 Two DPCHs with Same Data

If the two channels contain exactly the same data (PRBS data source with equal initial values), the individual components only differ in the channelization codes. Comparing any two lines of the channelization code matrix shows that 50% of the bits are identical and 50% are different (orthogonal matrix).
Where the bits are identical, the two channels furnish the same components, where the bits are different, the components cancel each other. The I/Q signal of this sum signal would then have the following characteristic:

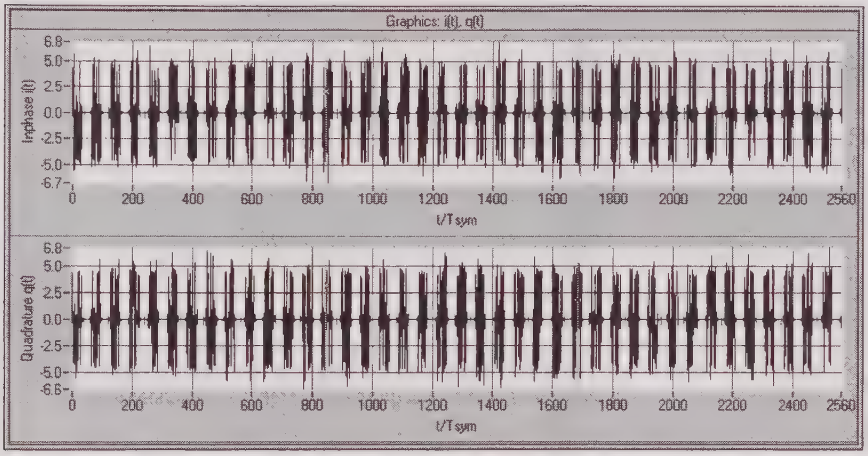


Fig. 8-61 Signal with two DPCHs (same data) in time domain

Note: *The bursts occurring at regular intervals are due to the use of the channelization code numbers 0 and 1. The two lines of the matrix are identical in the first half and different in the second half. Therefore, each of the 40 source symbols causes one of these bursts, the period of which is equivalent to half the symbol length. Other combinations of channelization code numbers often cause irregular results.*

The following associated constellation diagram is obtained:

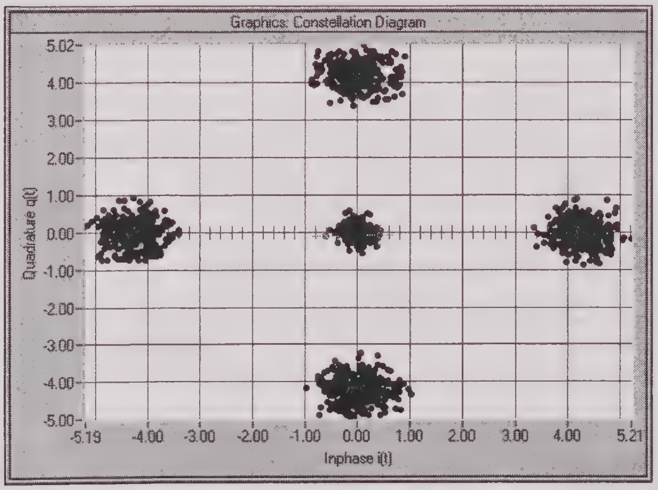


Fig. 8-62 Constellation of a signal with two DPCHs (uncorrelated data)

The new crest factor is 7.64 dB. Compared to section 8.3.2.1 the value has decreased since with constant peak value the average value has increased.

8.3.2.3 16 DPCHs with Uncorrelated Data

If the data of all channels are uncorrelated, the constellation diagram is obtained similarly to section 8.3.2.1 by multiple superposition of the basic constellation. Whether all possible points (channel number+1)^2 = 17*17 = 289 will be displayed depends on the data sequences and the sequence length.

Note: *In contrast to the previous constellation diagrams, all further diagrams were recorded with active receiver filter (root cosine 0.22). This allows better differentiation of the individual points. Setting of the receiver filter is described in section 5.17.*

Example for 16 time slots:

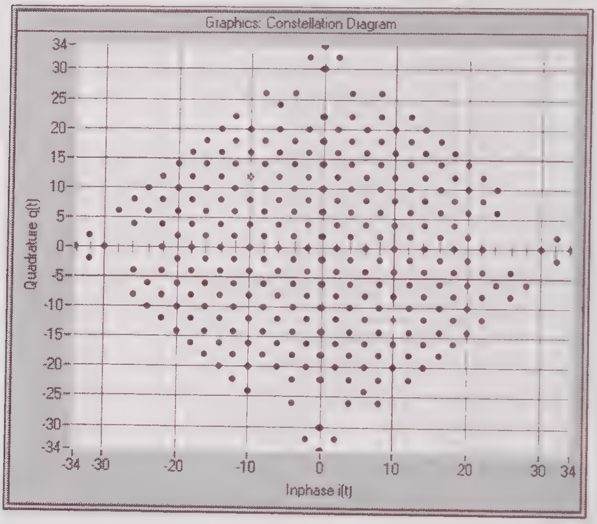


Fig. 8-63 Constellation with 16 uncorrelated channels (16 time slots)

This signal has a crest factor of 15.35 dB. The crest factor increases with the number of channels since the increase of the average value is slower than that of the peak value (cancelling effects).

The same diagram for a signal with one slot only is obtained:

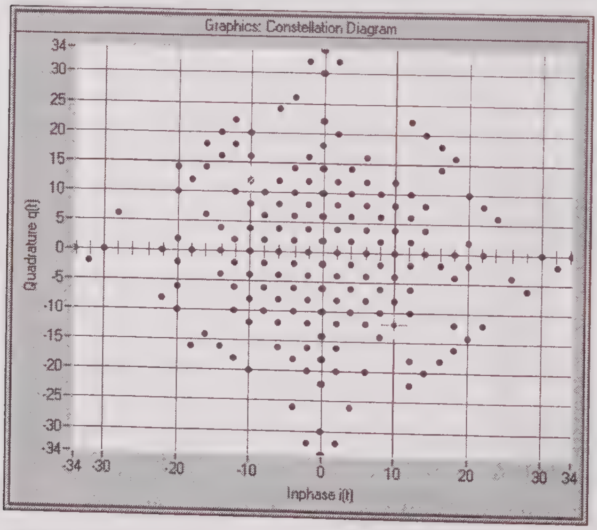


Fig. 8-64 Constellation with 16 uncorrelated channels (1 time slot)

The crest factor still has the value of 15.35 dB even if the CCDF has a different characteristic.

8.3.2.4 16 DPCHs with same Data

Similar to section 8.3.2.2 there are strong cancellation effects and there remain only points on the axes. The position of the points also depends on the choice of the channelization codes. The following diagram is an example for 16 channels, channelization code 0 to 15:

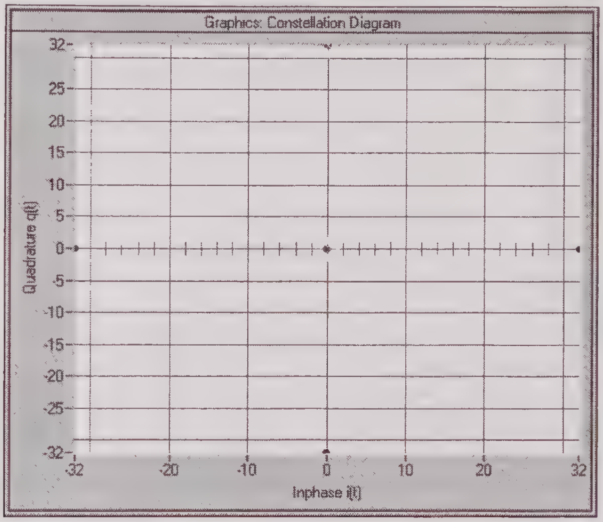


Fig. 8-65 Constellation diagram of 16 DPCHs with same data

In this case the crest factor is 16.17 dB. The value is so high because about 94 % of the points lie at the origin and only 6% of the points are at the outer positions.

8.3.2.5 Use of Timing Offset

All previous scenarios did not use a timing offset. Therefore all channels contained the same bits at least in the pilot symbol part. The result of this special feature was that the 4 corner points (0, 2*number of channels), (0, -2*number of channels), (2*number of channels, 0), (-2*number of channels, 0) where always there (constructive superposition).

Through the use of a timing offset (in our example 1 unit (=256 chips) from channel to channel) the data bits (including pilot and TPC) are shifted against each other.

Note: *In contrast to earlier versions of the W-CDMA standard or WinIQSIM, the timing offset (previously "data offset") is no longer defined in symbols but in units of 256 chips. Thus shifting becomes independent of the spreading factor.*

The worst case is thus eliminated, the crest factor becomes smaller and the spread symbols are arranged as follows:

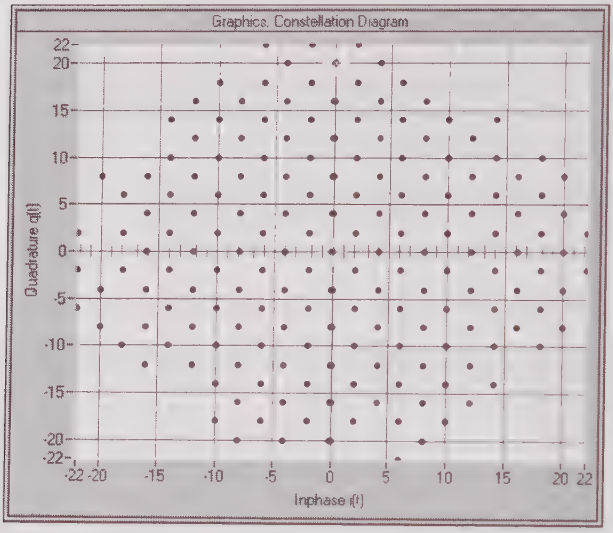


Fig. 8-66 Constellation diagram of 16 DPCHs with timing offset

Through the use of the timing offset the crest factor was reduced by approx. 4 dB to 12.26 dB.

The effect of the timing offset increases with the number of channels. If for instance 64 channels are used, the crest factor is reduced from 18.57 dB to 12.28 dB.

8.3.3 Effects on Crest Factor

The crest factor of the signal is mainly influenced by the following parameters:

- Link direction
  By modifying the Q component of the scrambling code in the uplink, it is possible to avoid every second zero crossing. In contrast to the downlink, the crest factor is reduced by approx. 1.8 dB. (Standard case DPCCH + 1DPDCH, the effect decreases with increasing number of channels.
- Timing offset (see 8.3.2.5)
  In the case of more than 10 channels, an increment of 1 (i.e. the first channel is assigned 0, the second 1, etc.) causes a low crest factor. With a small number of channels, an increment of 3 or 5 permits to obtain even better values.
- Sequence length if timing offset is active
  Longer sequences cause higher peak values and hence higher crest factors since the probability of even higher peak values increases.
- Number of channels
  More channels cause higher crest factors
- Selection of channelization codes
  Neighboring channelization codes usually cause higher crest factors than numbers distributed over the full range of available values.
- **Example:** 16 channels with channelization codes 0 to 15: 16.7 dB
  16 channels with channelization codes 0, 4, 8, to 60: 12,45 dB

Value of clipping level (see section 8.2.2.8)

Note: *In addition to the clipping level, the crest factor of the signal generated by AMIQ can also be reduced to any low level by overdriving in the quantization panel or by clipping (amplifier distortions). Since clipping takes place after filtering, it causes the spectrum to be dramatically widened.*

8.3.4 Orthogonality of Channels

To enable a 3GPP W-CDMA demodulator to restore the information of the individual channels from the sum signal, only certain combinations of

- scrambling code sequences,
- channel power and
- symbol rate and channelization codes

are allowed.

8.3.4.1 Ideal Scenario

In an ideal scenario the channel power measured (with code domain power analysers) is equal to the power transmitted (setting value in the channel configuration table), Even with great differences between the channel powers the information of the channels can be restored 100%. For this purpose however orthogonality of the channels is required. Orthogonality is given in all cases described in section 8.3.2. Orthogonality is given for instance if DPCH channels are used only and all of them have the same symbol rate but different channelization codes. In addition, identical scrambling code values have to be set for all channels, i.e. all channels have to belong to a base station.

In this case the bit streams SC_i and SC_q' are identical for all channels. Since the channelization code sequences of two channels are orthogonal, the chip sequences Si and Sq of two channels are also orthogonal.

8.3.4.2 Real Scenario

A real scenario usually consist of signals from different base/mobile stations that are operated at different scrambling codes and have different delays.

In this case there is no orthogonality, the channel powers are overlapping and the bit error rates increase with decreasing channel power (therefore power control is extremely important for all CDMA systems).

8.3.4.3 Effect of SCH

The SCH is not orthogonal to the DPCHs and all other downlink channels since the synchronisation code symbol is spread according to a special scheme (see section 8.1.1 System Components).

In the following example, the channels P-SCH, S-SCH, CPICH, P-CCPCH and two DPCHs (15 ksps to code 7 and 12) are included. If the SCH is compensated with the code domain power analysis, the channel powers can be determined ideally:

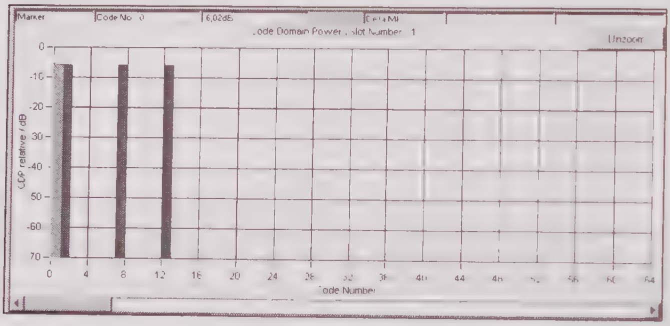


Fig. 8-67 CDPA of a signal with compensated SCH

If the SCH is not compensated, crosstalk to the other channels can be clearly seen:

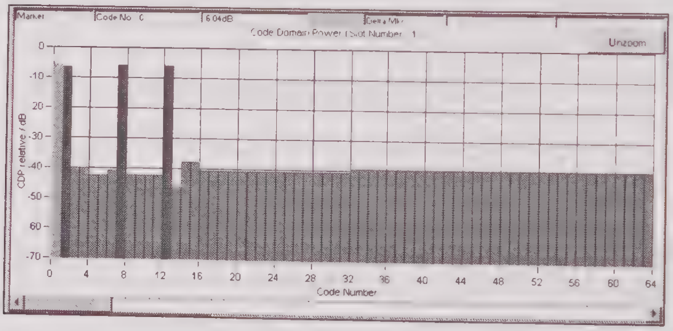


Fig. 8-68 Effect of SCH on CDP analysis (without compensation)

The channels transmitted are measured with an error of <0.2 dB. For all other channels a power of approx. -40 dB is determined.
These conditions still allow error-free decoding of all channels transmitted.

8.3.4.4 Effect of S-CCPCH and the Other Downlink Channels

Like a DPCH, S-CCPCH, P-CPICH, S-CPICH, PDSCH, PICH, AICH and DL-DPCCH are spread with the same symbol rate. Therefore the same conditions as for DPCHs apply to the parameters of these channels.(see section 8.3.4.7)

8.3.4.5 Effect of PRACH and PCPCH

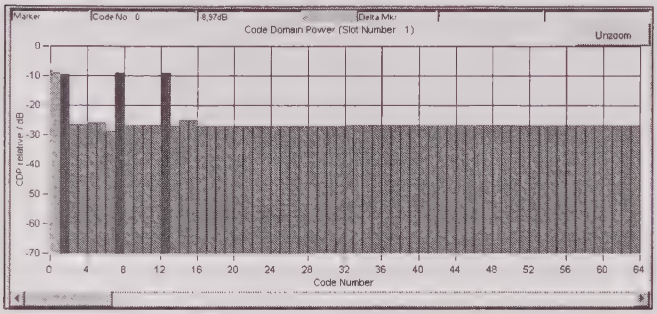
The PRACH and the PCPCH are not orthogonal to DPCCH and DPDCHs since the scrambling code is formed differently. Mobile stations never use PRACH or PCPCH and DPCCH/DPDCH simultaneously – therefore mixed operation is only possible in WinIQSIM if these channel types are distributed to different stations (e.g. MS1 and MS2).

8.3.4.6 Effect of Scrambling Code

The scrambling code permits to distinguish between base stations (downlink) and mobile stations (uplink).

If different scrambling codes are used within a signal (in this example, the scenario under 8.3.4.3 is coded twice with different scrambling codes), the orthogonality between the channels will be lost.

The following example shows the level conditions measured after despreading:



Marker Code No 0 -8,97dB

Fig. 8-69 Effect of different scrambling codes on the power distribution

These conditions still allow error-free reconstruction of the bit streams. A certain guard interval should however always be observed between the transmitted channel power and the measured power of the other (non-orthogonal) channels.
In this example a channel power of -10 dB is sufficient for error-free decoding, whereas with a power of -15 dB the bit error rate is about 10 % already. (The given values were evaluated at the physical layer using a CDPA. Even worse conditions allow error-free reconstruction of the bit stream through channel coding!)

8.3.4.7 Effect of Symbol Rates and Channelization Code Numbers

The channelization code generation method has the effect that with certain symbol rate/channelization code combinations the identical spreading sequences Si/Sq are generated. This is always the case with channelization code number 0 (all bits 0), but also with the combination 960 ksps/channelization code 1 (0011) <-> 480 ksps/channelization code 2 (00110011).

As a rule, the spreading sequences are identical if the products of symbol rate and channelization code are identical.

The despreader therefore can no longer differentiate between the two channels. Depending on the data contents, the channel powers are either added up or cancel each other. Restoring of all source data is not possible.

Note: *Identical or overlapping areas in the code domain are indicated by WinIQSIM with a red LED* ●.

The following signal contains

- a DPCH with 960 ksps, channelization code number 1, 0 dB, data all 0
- a DPCH with 480 ksps, channelization code number 2, 0 dB, data all 1

An analysis at 960 ksps gives the following result:

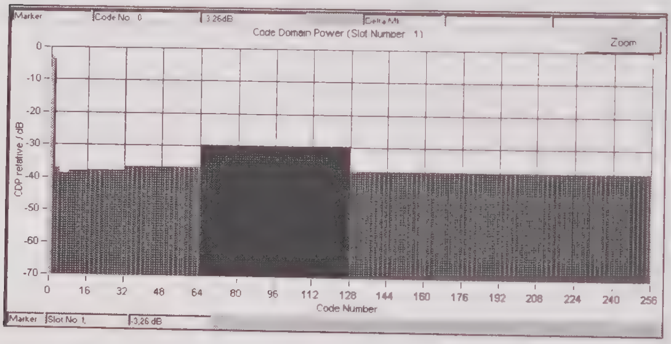


Fig. 8-70 Cancellation possible in case of several channels with identical spreading sequences

Apart from this trivial case there are other cases in which problems may occur.
The above example is modified by changing the channelization code of the second DPCH from 2 to 3:

- a DPCH with 960 ksps, channelization code 1, 0 dB, data all 0
- a DPCH with 480 ksps, channelization code 3, 0 dB, data all 1

After despreading at symbol rate 480 ksps, the following power distribution is obtained:

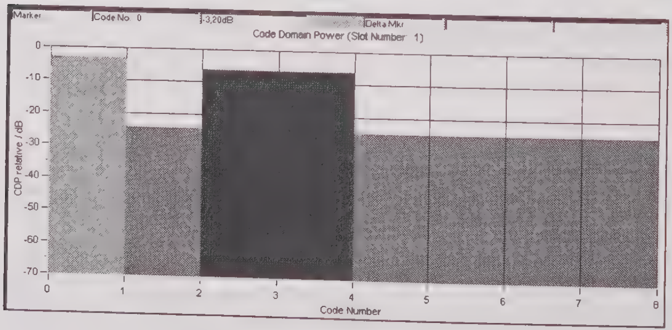


Fig. 8-71 Incorrect detection at various symbol rates

The 960-ksps channel (channelization code 1) is detected as channel 2 at 480 ksps. There is however no crosstalk to channel 3. Therefore the 480-ksps channel is detected with the original power and all bits can be restored.

Despreading of the 960-ksps channel however gives the following power distribution:

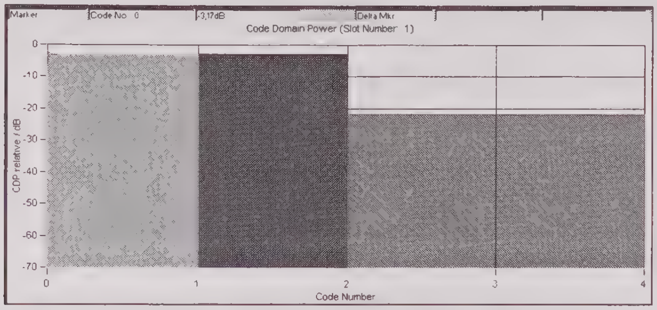


Fig. 8-72 Non-restorable DPCH channel

Both channels synchronise with channel 1, despreading is no longer possible with these level conditions.

For despreading all transmitted DPCHs, two channels of half the symbol rate (channelization codes 2n, 2n+1) should therefore be avoided for each channel used with a certain symbol rate (channelization code n). This is continued for four channels of one fourth of the symbol rate (channelization codes 4n, 4n+1, 4n+2, 4n+3), etc.

For further information refer to section 8.2.2.5.6.

8.3.5 Simulation of Special Scenarios

It is shown in the following how special scenarios can be simulated by means of WinIQSIM parameters. The downlink is used as an example, since a mobile station can always be completely implemented in an MS.
Scenario 8.3.5.4 for the simulation of several base stations can also be applied to the simulation of mobile station signals.

Note: *Section 8.2.2.4 describes a particularly simple method for setting a base station.*

8.3.5.1 Standard Base Station

A standard base station is the easiest example of a base station.

- Activate the channels P-CPICH, P-SCH, S-SCH and P-CCPCH (State = ON). These channels are absolutely necessary for the synchronization of a mobile station with the signal.
- Activate between 0 and 128 DPCHs.
- Select channelization codes and symbol rates so that no code domain conflicts occur.
- Use timing offset in channels to model the offsets T_{DPCH}, T_{PICH}, $T_{S\text{-}CCPCH}$ ([1], section 7) as specified in the 3GPP W-CDMA standard.
- Set a valid combination of scrambling code and 2nd Search Code Group. (For details refer to [2] 5.2.2)

In [3], Appendix D, a few test models are specified that have been designed for certain tests. These scenarios are supplied as WinIQSIM setups and can be found in the subdirectory **\examples\3GPP_test_models** :

File name	**Use**
TestModel1_16channels.iqs	Spectrum emission mask ACLR Spurious emissions Transmit intermodulation Modulation accuracy
TestModel1_32channels.iqs	
TestModel1_64channels.iqs	
TestModel2.iqs	Output power dynamics
TestModel3_16channels.iqs	Peak code domain error
TestModel3_32channels.iqs	
TestModel1_16channels	
TestModel4.iqs	Error vector magnitude

8.3.5.2 Base Station with more than 128 DPCHs

To avoid the channel table becoming unclear, a BS in WinIQSIM may contain a maximum of 128 DPCHs. If a base station is to be simulated with more than 128 DPCHs, these channels have to be distributed to several BS.

- Make the same settings as under 8.3.5.1 for the first BS.
- Assign the remaining DPCHs to the other BSs.
- Select the channelization codes and symbol rates so that no code domain conflicts occur, even beyond the limits of a BS.

Note: *WinIQSIM does not support code domain power (conflict) display beyond the limits of a MS/BS. If several stations are available it is useful to divide the available range in subranges (e.g. BS1 : 0 to 256, BS2 : 257 to 467, BS3: 468 to 511).*

- Set the same value and type for the scrambling code for all BSs.

  Note: *The function "Copy BS/MS", as described in 8.3.4.6, facilitates the transfer of these values from one BS to another.*

8.3.5.3 Base Stations with Spreading Codes Used Several Times

3GPP W-CDMA envisages the increase of the number of channels using primary and secondary scrambling codes.
The PCCPCH and the first part of DPCHs is then sent with the primary scrambling code, the remaining DPCHs with one of the assigned secondary scrambling codes. The following range of values is given in [2]:
Primary scrambling code : n = 16 * i with i=0 to 511
Secondary scrambling code : n = 16 * i + k with i=0 to 511 and k=1 to 15

Note: *The use of secondary scrambling codes principally yields the same results as the parameter T_{offset} specified in former standards.*

When the secondary scrambling codes are used, orthogonality is impaired and crosstalk is produced (see 8.1.1.1).
This scrambling code can be entered for a BS. If channels with different scrambling codes are to be simulated, a division into several BSs is required as described under 8.3.5.2 :

- Set several BSs according to 8.3.5.1. The special channels (SCH, CPICH, ...) will be activated in one BS only!
- Set the desired values for the scrambling code for all BSs.

8.3.5.4 Several Base Stations

3GPP W-CDMA base stations can be at different RF frequencies. This case can be simulated in the multicarrier mixed signal system (see section 10).
Since there are normally not enough frequencies available, the base stations within a transmit frequency are distinguished by the primary scrambling code .

- Set several BSs according to 8.3.5.1.
- Set the desired values for the scrambling code for all BSs.

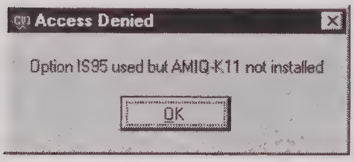
Note: *A maximum of four base or mobile stations can be simulated in the 3GPP W-CDMA system with WinIQSIM. If this number is not sufficient (in practice, this will be the case in particular with uplink signals), the number of stations can be increased considerably using the system "Multi-Carrier Mixed Signal" (see chapter 10) or the function "Add Signal" (see 5.16.3).*

9 IS-95

WinIQSIM is able to generate CDMA signals complying with the mobile standards IS-95A and J-STD-008. Chapter 9.1 explains the components of an IS-95 system and the layer where the signal can be simulated.

Chapter 9.2 describes the possible operations which enable the user to calculate an IS-95 signal with WinIQSIM.

To be able to load the IS-95 signal into the AMIQ, the option AMIQ-K11 must be installed there. Otherwise, the following message appears:



Option IS95 used but AMIQ-K11 not installed

Fig. 9-1 Message if AMIQ-K11 is not installed

The installation of software options is described in the Operating Manual for AMIQ.

9.1 Description of the Mobile Standard IS-95

IS-95 is the best known CDMA mobile standard. There is one version (IS-95A) for the 800-MHz band and one version (J-STD-008) for the 1800-MHz band. The differences between the two methods are the frequency range and the higher protocol layers.

As WinIQSIM simulates the signals only at the physical layer, no differentiation is required in the program. In the following, both methods will be referred to as "IS-95".

9.1.1 Forward Link

"Forward Link" refers to the direction from the base station to the mobile station.

WinIQSIM can simulate up to 8 base stations. Each of these base stations can contain up to 64 active channels.

To be able to separate the 64 channels of a base station in the mobile station, they must be orthogonal to each other. This is enforced by the use of one of 64 Walsh functions. The number of the Walsh function corresponds to the channel number.

WinIQSIM performs no channel coding, the individual channels are generated according to the following diagram:

Pilot Channel

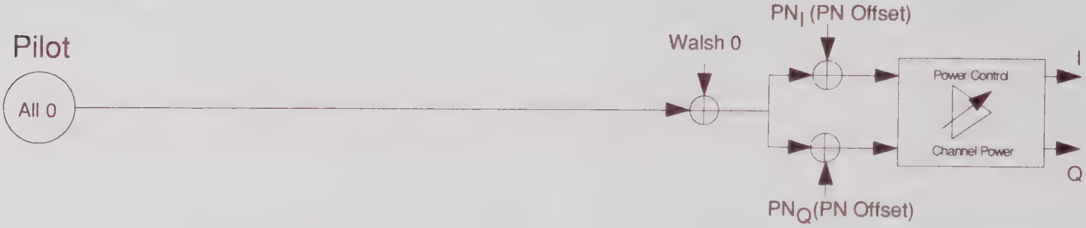


Fig. 9-2 Pilot Channel

The pilot channel is operated with the data "All 0". As a result of spreading with "Walsh 0" the bit sequences are identical to the PN sequences after applying the PN generators.
Each base station contains one pilot channel (Walsh 0).

Sync Channel

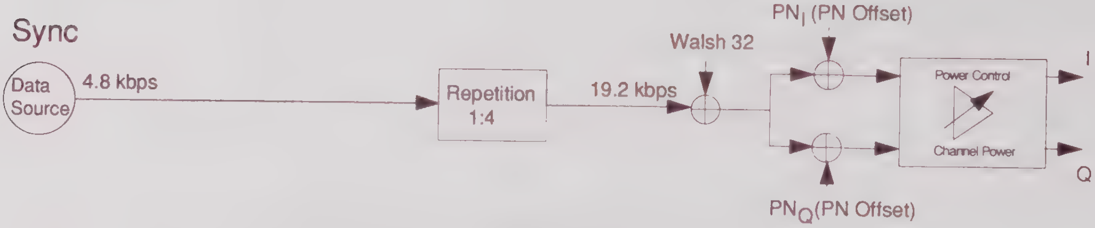


Fig. 9-3 Sync Channel

Any data source can be used for the sync channel. The data are derived from it with a rate of 4800 bps and subsequently quadrupled. Walsh 32 is then applied to this data stream, increasing the data rate to 19.2 kbps * 64 = 1.2288 Mcps.
Each base station contains one sync channel (Walsh 32).

Paging Channel

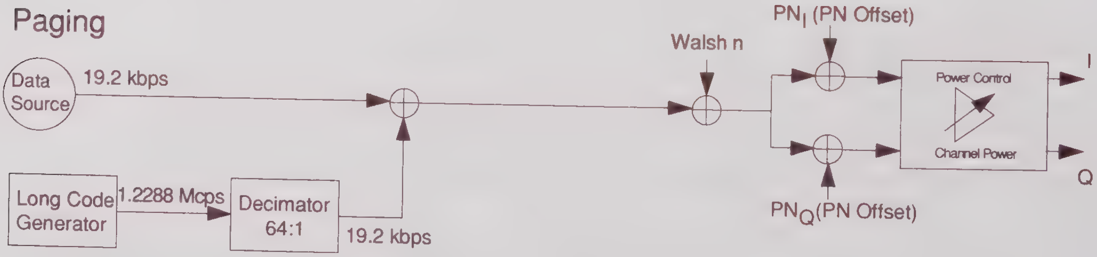


Fig. 9-4 Paging Channel

Any data source can be used for the paging channel. The data are derived with a rate of 19200 bps and finally scrambled with a long code sequence of the same rate. This sequence is derived from a long code generator the bit stream of which can be shifted in time by masking with the long code mask. Since the generator runs with a chip rate of 1.2288 Mcps, the sequence is decimated by the factor 64.

A base station may contain up to 7 paging channels in the range [Walsh 1 to Walsh 7].

Traffic Channel

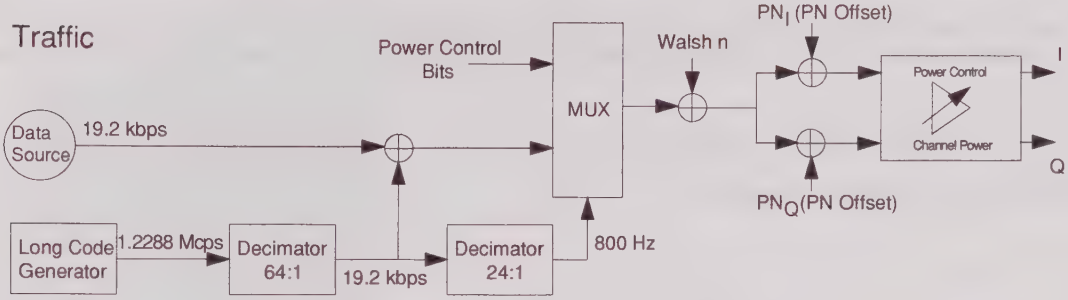


Fig. 9-5 Traffic Channel

Traffic channels are similar to paging channels in their design. The only difference lies in the multiplexer, which derives a power control bit instead of the scrambled data bits at a rate of 800 Hz.

A base station may contain up to 62 traffic channels in the range [Walsh 1 to Walsh 31, Walsh 33 to Walsh 63].

Composition of the forward link signal from the contributions of the individual channels

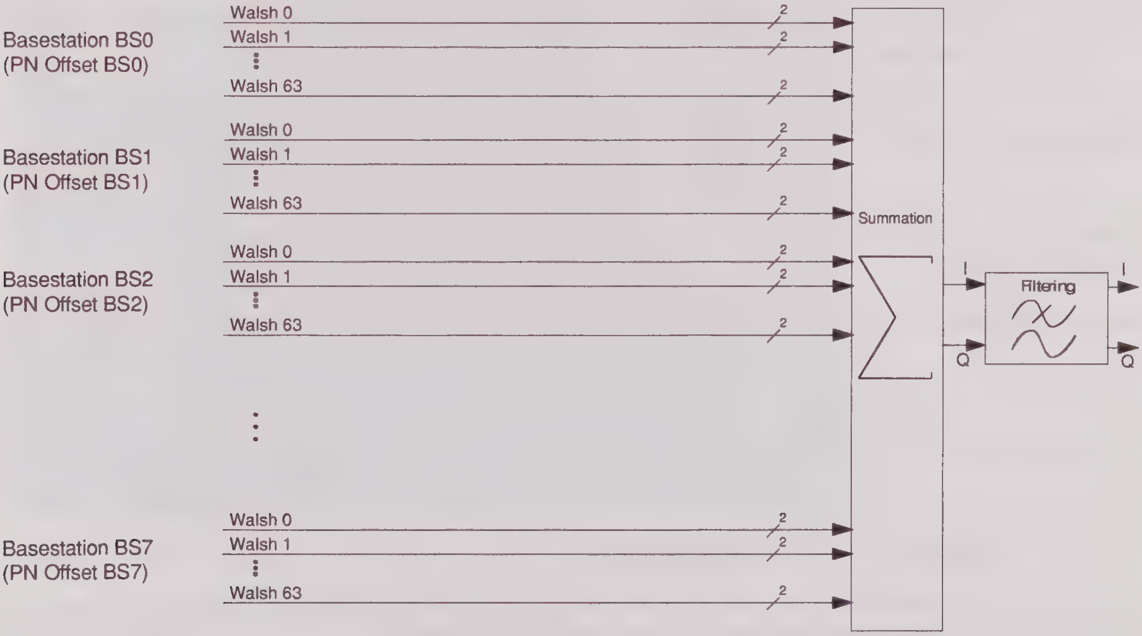


Fig. 9-6 Composition of the forward link signal

The complex channel contributions of the various base stations are summed up and subsequently filtered.

For each base station, a PN offset can be defined in the range [0 to 511].

9.1.2 Reverse Link

"Reverse Link" refers to the direction from the mobile station to the base station.
WinIQSIM can simulate up to 16 mobile stations. Each of these mobile stations contains exactly one channel.

The two channel types "Access Channel" and "Traffic Channel" only differ in the structure of the long code mask.
A reverse link channel is built up as follows:

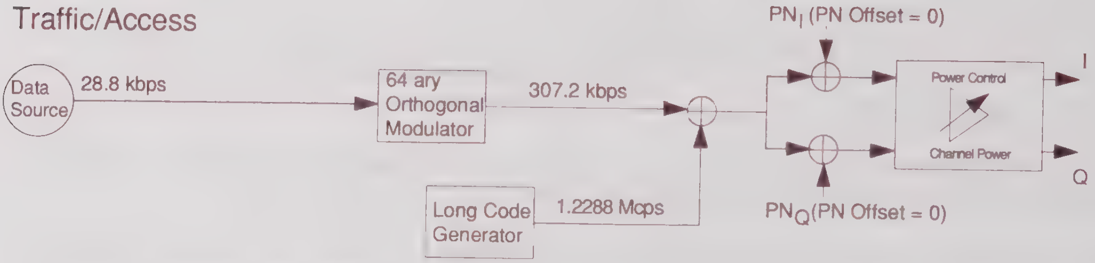


Fig. 9-7 Reverse Link Channel

Any data source can be used for the reverse link channel. The data are derived with a rate of 28800 bps. The 64-fold orthogonal modulator produces 64 output bits from 6 input bits, increasing the data rate by the factor 64/6 to 307.2 kbps. This bit stream is scrambled with the output of the long code generator and then applied to the two PN generators in parallel. As a special feature of the reverse link, these generators are operated with the offset 0.

Composition of the reverse link signal of the contributions of the individual channels

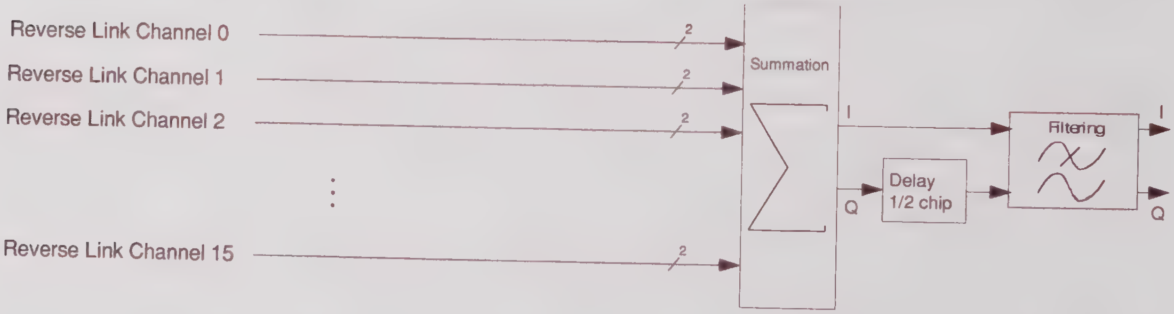
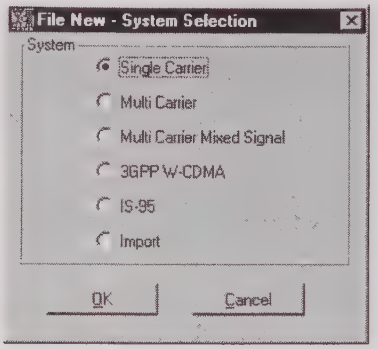


Fig. 9-8 Composition of the reverse link signal

The delay in the Q line drawn in causes an O(ffset) QPSK modulation.

9.2 Generation of IS-95 Signals with WinIQSIM

To generate an IS-95 signal, the IS-95 system must be selected first.


File New - System Selection

System

● Single Carrier
○ Multi Carrier
○ Multi Carrier Mixed Signal
○ 3GPP W-CDMA
○ IS-95
○ Import

Fig. 9-9 IS-95 system selection

The system can be selected both via "File/New..." and via the menu item "System!".
The differences between the two methods are described in 5.22.1/5.23.

Except for the block "IS-95 Configuration", the block diagram is identical to that of W-CDMA.

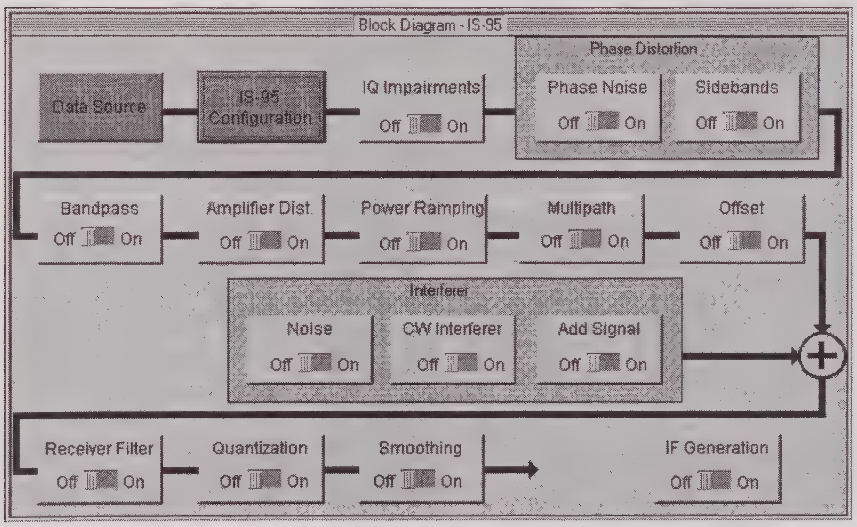
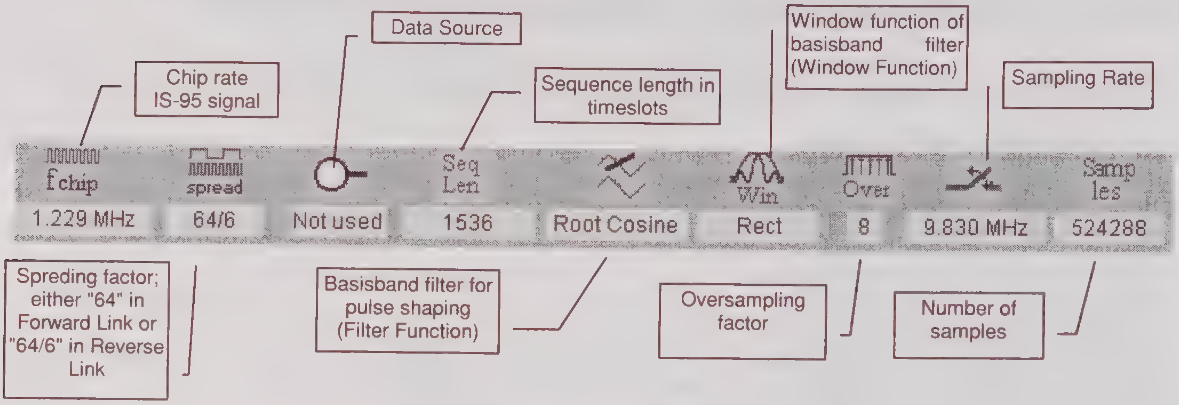


Fig. 9-10 Block diagram of IS-95 system

The data source block corresponds to that of the multicarrier system. For description of the data source refer to chapter 7.2.

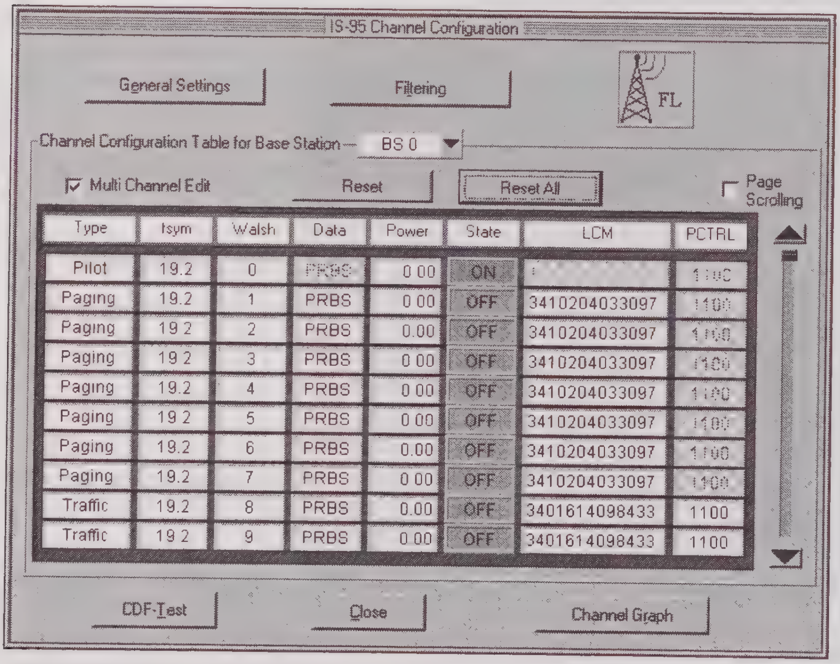
9.2.1 Status Line

The main parameters of the IS-95 system are displayed in the status line below the toolbar. Thus the set parameters can be seen at a glance.
The status line consists of symbols for the different parameters and the values of these parameters.


Data Source
Window function of basisband filter (Window Function)
Chip rate IS-95 signal
Sequence length in timeslots
Sampling Rate
fchip
spread
Seq Len
Win
Over
Samp les
1.229 MHz
64/6
Not used
1536
Root Cosine
Rect
8
9.830 MHz
524288
Spreding factor; either "64" in Forward Link or "64/6" in Reverse Link
Basisband filter for pulse shaping (Filter Function)
Oversampling factor
Number of samples

9.2.2 IS-95 Configuration Panel

All parameters of the IS-95 signal (except the definition of the data sources and impairments) can be set via this panel.



Channel Configuration Table for Base Station — BS 0

☑ Multi Channel Edit

☐ Page Scrolling

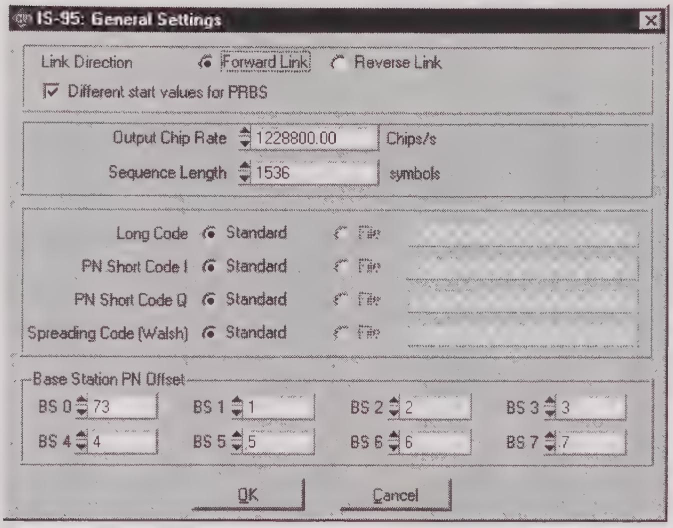
Type	fsym	Walsh	Data	Power	State	LCM	PCTRL
Pilot	19.2	0	PRBS	0.00	ON		1100
Paging	19.2	1	PRBS	0.00	OFF	3410204033097	1100
Paging	19.2	2	PRBS	0.00	OFF	3410204033097	1100
Paging	19.2	3	PRBS	0.00	OFF	3410204033097	1100
Paging	19.2	4	PRBS	0.00	OFF	3410204033097	1100
Paging	19.2	5	PRBS	0.00	OFF	3410204033097	1100
Paging	19.2	6	PRBS	0.00	OFF	3410204033097	1100
Paging	19.2	7	PRBS	0.00	OFF	3410204033097	1100
Traffic	19.2	8	PRBS	0.00	OFF	3401614098433	1100
Traffic	19.2	9	PRBS	0.00	OFF	3401614098433	1100

Fig. 9-11 IS-95 Configuration Panel

This panel consists of the Channel Configuration Table which contains channel-specific settings. Two buttons are provided above this table for starting secondary panels, which allow the definition of settings referring to several channels (General Settings) and of parameters for baseband filtering (Filtering).

Another two buttons are provided below the table for display of the complementary cumulative distribution function (CDF test) and for on overview of all active channels (Channel Graph).

9.2.2.1 General Settings


IS-95: General Settings

Link Direction ● Forward Link ○ Reverse Link

☑ Different start values for PRBS

Output Chip Rate 1228800.00 Chips/s

Sequence Length 1536 symbols

Long Code ● Standard ○ File

PN Short Code I ● Standard ○ File

PN Short Code Q ● Standard ○ File

Spreading Code (Walsh) ● Standard ○ File

Base Station PN Offset

BS 0 73 BS 1 1 BS 2 2 BS 3 3

BS 4 4 BS 5 5 BS 6 6 BS 7 7

Fig. 9-12 General Settings

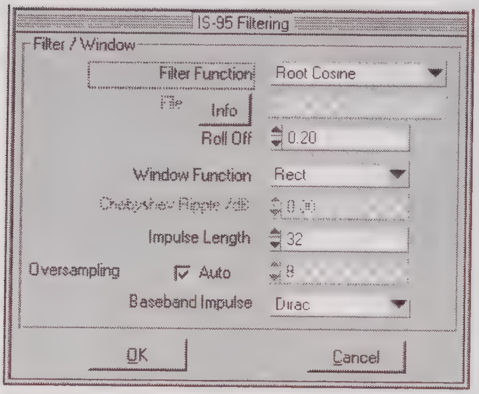
The following parameters are defined in this panel:

- Link Direction
  Forward link, ie from the base station to the mobile station, or reverse link, ie from the mobile station to the base station
- Different start values for PRBS
  If this button is active, the PRBS generators of the individual channels are initialized with different start values. As a result, all channels are calculated with independent source data.

  Note: *This button is only effective for the data source with the name "Data Source PRBS"! If for instance the data source with the designation "Data Source 0" is used with PRBS16, this button is ignored, ie all channels using data source 0 are calculated with identical PRBS bit sequences!*
- Output Chip Rate
  This parameter defines the actual chip rate of the output signal. This value defines the rate of the spread symbols used for signal output by the AMIQ. The standard setting of this value is 1228800 chips/s.
- Sequence Length
  The length of the signal to be generated is set here in source symbols. The data rate 192 kbps is used in forward link and 28.8 kbps in reverse link.
  The sequence length can be varied in certain increments only:
  Forward Link: ±4 (as sync channel is calculated with 4.8 kbps and therefore only a quarter of the defined bits is derived from the data source)
  Reverse Link: ±6 (as in the orthogonal modulator always groups of six bits are used for addressing a line of the Walsh table)
  Long Code/Short Code/Spreading Code
  This version only supports the settings that are in line with the standard.
- Base Station PN Offset
  A PN offset can be set for each base station. This value is used as time offset of the PN generators with forward link signals. The value range is [0 to 511]

9.2.2.2 Filtering

The generated raw chips are subjected to baseband filtering which is implemented equivalent to the single carrier system.



Filter / Window

Filter Function: Root Cosine

File

Roll Off: 0.20

Window Function: Rect

Chebyshev Ripple /dB: [illegible]

Impulse Length: 32

Oversampling: ☑ Auto 8

Baseband Impulse: Dirac

Fig. 9-13 IS-95 Filtering

The description of the individual parameters can therefore be found in chapter 5.8 Modulation Setting Panel.

IS-95 defines special baseband and phase equalization filters.
The subdirectory examples\is95 contains a few filter files that have been optimized for certain scenarios. All these filters comply with the IS95 specifications in terms of their transmission function.

Table 9-1 Appropriate user filters for IS-95

Filter file	**Link Direction**	**Phase equalization**	**Optimization**
CDMA_BS.IFL	Forward	yes	Low Adjacent Channel Power (ACP)
CDMA_MS_FL	Reverse	no	Low Adjacent Channel Power (ACP)
CDMABS95.IFL	Forward	yes	Original filter coefficients
CDMAMS95.IFL	Reverse	no	Original filter coefficients
CDMAPILO.IFL	Forward	yes	Low Adjacent Channel Power (ACP), in particular for signals containing only pilot

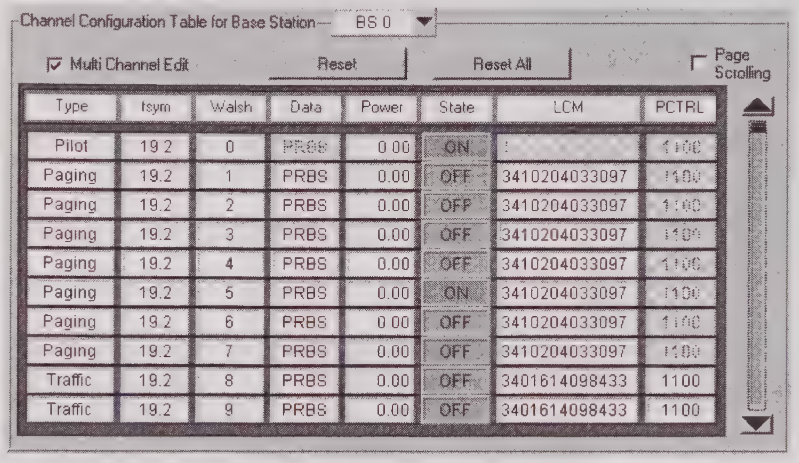
To select one of these filters select "User" as filter function and then the appropriate file name.

9.2.2.3 Link Direction Icon

In the upper right corner of the Channel Configuration panel there is an icon which symbolizes the currently selected link direction:
FL for forward link, RL for reverse link.

9.2.2.4 Channel Configuration Table

This table contains all data which can be set individually for each channel. Each line corresponds to one channel. The tables for forward and reverse link differ only slightly. The following illustration shows the channel table for the forward link:



Type	tsym	Walsh	Data	Power	State	LCM	PCTRL
Pilot	19.2	0	PRBS	0.00	ON		1100
Paging	19.2	1	PRBS	0.00	OFF	3410204033097	1100
Paging	19.2	2	PRBS	0.00	OFF	3410204033097	1100
Paging	19.2	3	PRBS	0.00	OFF	3410204033097	1100
Paging	19.2	4	PRBS	0.00	OFF	3410204033097	1100
Paging	19.2	5	PRBS	0.00	ON	3410204033097	1100
Paging	19.2	6	PRBS	0.00	OFF	3410204033097	1100
Paging	19.2	7	PRBS	0.00	OFF	3410204033097	1100
Traffic	19.2	8	PRBS	0.00	OFF	3401614098433	1100
Traffic	19.2	9	PRBS	0.00	OFF	3401614098433	1100

Fig. 9-14 Channel Configuration Table for forward link

For changing the displayed range and activating the channels refer to W-CDMA (see section 8.2.2.4)

Channel types in forward link

There is a fixed link between Walsh (= channel) numbers and the channel types offered.

Table 9-2 Possible channel types depending on the Walsh number

Walsh	Possible channel types
0	Pilot
1..7	Paging or Traffic
8..31	Traffic
32	Sync
33..63	Traffic

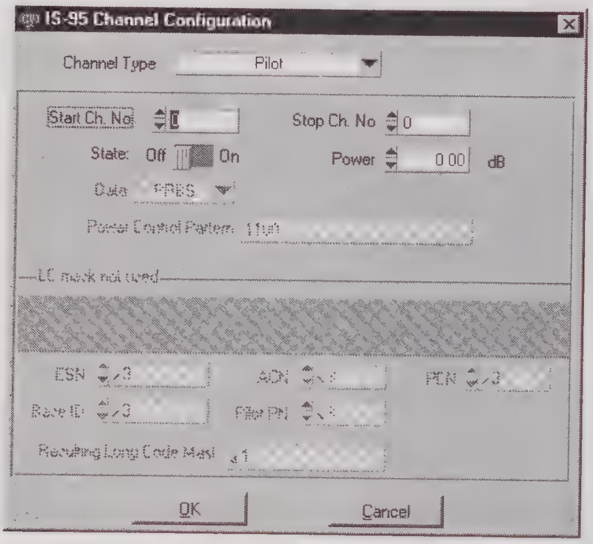
Channel types in reverse link

Each of the 16 channels can be configured both as traffic and as access channel.

Selection of the base station

The control element BS 0 permits to select the current base station (only forward link). Each base station may contain up to 64 channels which are all coded with the same PN offset. This PN offset is defined in the General Settings (9.2.2.1).

Parameters of the pilot channel

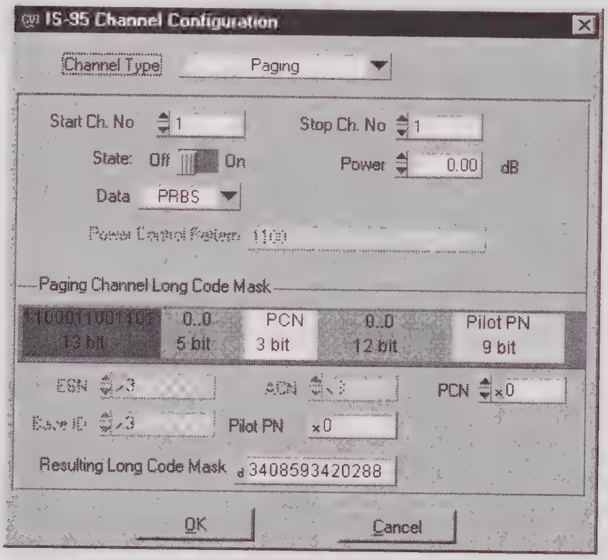


Channel Type: Pilot
Start Ch. No: 0
Stop Ch. No: 0
State: Off / On
Power: 0.00 dB

Fig. 9-15 Parameters of pilot channel

With this channel type, only the state and the channel power can be defined.
This channel is only used in forward link.
The channel number (Walsh) is always 0.

Parameters of the paging channel



Channel Type: Paging
Start Ch. No: 1
Stop Ch. No: 1
State: Off / On
Power: 0.00 dB
Data: PRBS

Paging Channel Long Code Mask

1100011001101	0..0	PCN	0..0	Pilot PN
13 bit	5 bit	3 bit	12 bit	9 bit

PCN: x 0
Pilot PN: x 0
Resulting Long Code Mask: d 3408593420288

Fig. 9-16 Parameters of paging channel

The channels in the range 1 to 7 can be used both as paging and as traffic channels in the forward link. For switching over between these types, the Channel Type button is used.

- Start Ch. No / Stop Ch. No
  These two values are used to define the channel range to which the other parameters are to be applied.

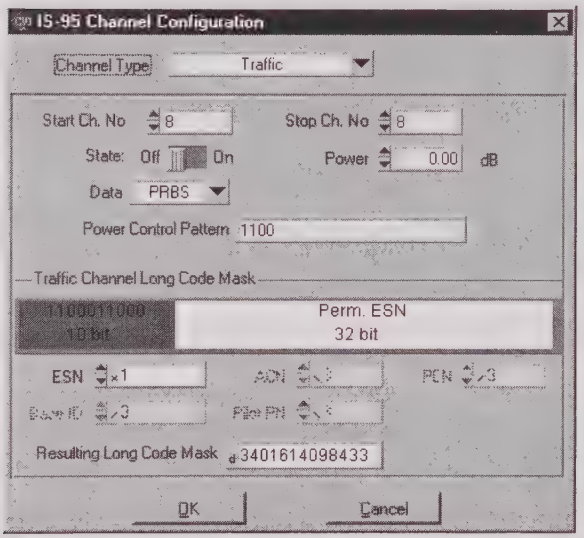
- State/Power
  State and power of the channels are defined here.

Note: *The given powers refer to a mapping where all four constellation points lie on the circle.*

- Data
  Selection of one of the preset data sources Data 0, Data 1, Data 2 or PRBS These data sources are determined as described in section 7.2.
- Long Code Mask
  All other fields are used for editing the long code mask. The graph shows the structure of the mask which depends on the channel type.
  The long code mask consists of 42 bits, some of which are constant.
  The pilot PN (offset) is taken from the General settings and cannot be changed.
  PCN: Paging Channel Number [0 to 7]

  The last line indicates the value of the mask in decimal form as it is displayed in the channel table.

Parameters of (Forward)Traffic Channel



Channel Type: Traffic
Start Ch. No 8
Stop Ch. No 8
State: Off On
Power 0.00 dB
Data PRBS
Power Control Pattern 1100
ESN x1
Resulting Long Code Mask d3401614098433

Fig. 9-17 Parameters of (Forward) Traffic Channel

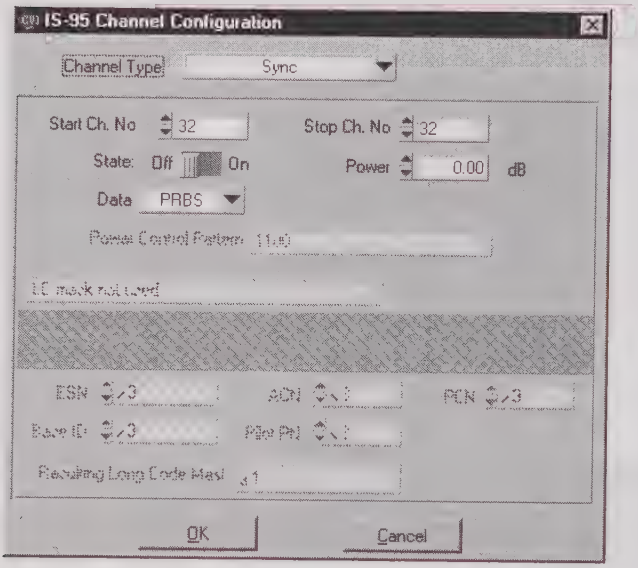
This channel type can be selected for forward link signals in the ranges [1 to 7], [8 to 31] and [33 to 63].

Note: *Since there is a fixed link between Walsh (= channel) numbers and the channel types offered, it is not possible to set the maximum of 62 traffic channels in one block.*

The possibilities differ from those of the paging channel in two items:

- Power Control Pattern
  These bits are faded into the bit stream at a rate of 800 Hz instead of the scrambled data bits. If the given pattern is shorter than is required for the given sequence, it is repeated cyclically.
- Long Code Mask
  The variable part consists of 32 bits, the "Permuted ESN".

Parameters of the Sync Channel



Channel Type: Sync

Start Ch. No: 32

Stop Ch. No: 32

State: Off On

Power: 0.00 dB

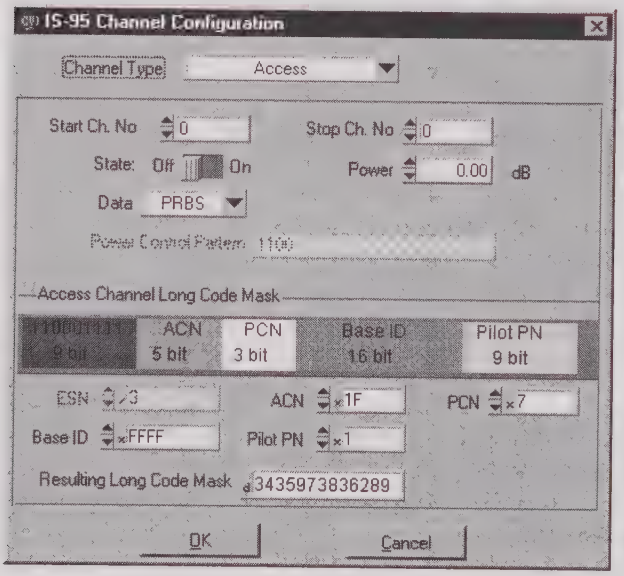
Data: PRBS

LC mask not used

Fig. 9-18 Parameters of sync channel

This channel type is only possible for channel 32 of the forward link.
When specifying the data source bear in mind that only ¼ of the set sequence length is derived from this data source, since this channel is operated with 4800 bps.

Parameters of the Access Channel



Channel Type: Access

Start Ch. No: 0

Stop Ch. No: 0

State: Off On

Power: 0.00 dB

Data: PRBS

ACN: x1F

PCN: x7

Base ID: xFFFF

Pilot PN: x1

Resulting Long Code Mask: d3435973836289

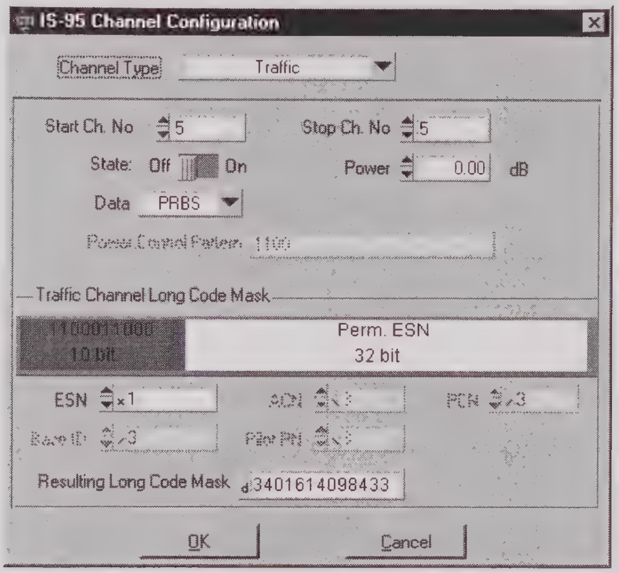
Fig. 9-19 Parameters of access channel

The access channel can be selected for all channels [0 to 15] in the reverse link.
Its parameters differ from those of the paging channel only in the components of the long code mask:

- ACN: Access Channel Number

- PCN: Paging Channel Number
- Base ID: Base Station Identification
- Pilot PN: PN offset of the Forward CDMA channel

Parameters of the Reverse Traffic Channel



Channel Type: Traffic
Start Ch. No: 5
Stop Ch. No: 5
State: Off / On
Power: 0.00 dB
Data: PRBS
Power Control Pattern: 1100
ESN: x1
Resulting Long Code Mask: d3401614098433

Fig. 9.20 Parameters of Reverse Traffic Channel

The reverse traffic channel can be selected for all channels [0 to 15] in the reverse link. Contrary to the forward traffic channel, no power control pattern can be specified here.

Multi Channel Edit button

This button allows simple editing of a group of channels.
Upon closing a Configuration panel with OK, the range of the set channels is internally noted.

If this button is activated and one of these channels is selected, the configuration dialog is displayed with the same parameters that were valid when the channel settings were changed last.

If the button is deactivated, Start Ch. No and Stop Ch. No are set to the same currently selected channel. This mode is to be preferred when only a single channel has to be changed.

For setting a group of channels it is recommended to proceed as follows:

- ➢ Activate the "Multi Channel Edit" button.
- ➢ Click on one of the channels to be changed and make all the settings that are to be valid for all channels in the Configuration Panel.
- ➢ Quit the panel with OK and deactivate the Multi Channel Edit button.
- ➢ Edit each channel separately the parameters of which differ from the global settings of step 2.

Reset button

Pressing this button resets all values of the Channel table to standard values. In the case of forward link signals, this only applies to the channels of the currently selected base station, the channels of all base stations are completely reset by means of **Reset All**.
The reset values depend on the channel type.

Table 9-3 Reset values

Channel type	Reset values
Pilot Channel	-
Sync Channel	Data = PRBS
Paging Channel	Data = PRBS, PCN = 0x0
Forward Traffic Channel	Data = PRBS, Power Control Bits = 1100, ESN = 1
Access Channel	Data = PRBS, ACN = 0x1F, PCN = 0x7, Base ID = 0xFFFF, Pilot PN = 1
Reverse Traffic Channel	Data = PRBS, ESN = 1

In addition, all channels are switched off (State = OFF, Power = 0.0 dB).

9.2.2.5 CDF Test

A "complementary cumulative distribution function "can be generated from the filtered I/Q samples. This function gives the probability of the magnitude of complex samples exceeding a predefined threshold.

For the description of this panel refer to 8.2.2.5.

9.2.2.6 Channel Graph

This graph shows all active channels at a glance.
Only the channels of the currently selected base station are displayed in the forward link.

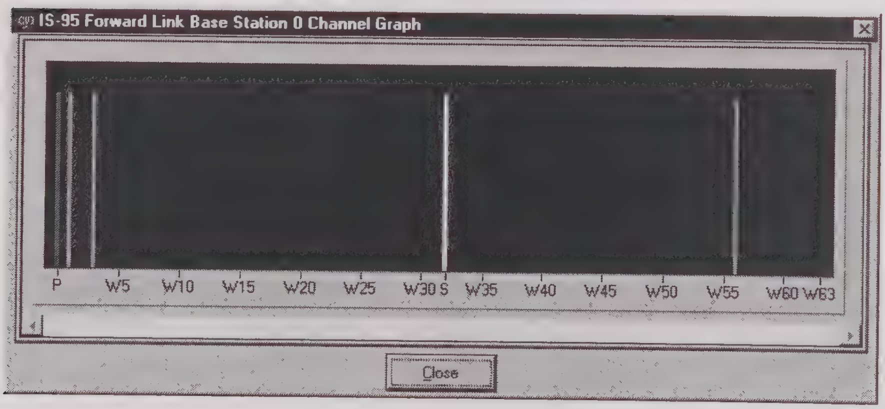


Fig. 9-20 Channel Graph

The channel power can be seen from the length of the line.
The colour can be used to differentiate between channel types.
Pilot: red
Paging/Traffic: green
Sync/Access: yellow

10 Multicarrier Mixed Signal

In contrast to multicarrier signals generated with multicarrier systems, which can contain modulated carriers of one digital modulation type only, the multicarrier mixed signal system allows the combination of any modulation types and signals of different systems. A scenario can be devised for up to 32 carriers with a freely selectable but constant frequency spacing. A different signal generated with any WinIQSIM system can be modulated onto each of these carriers. It is, for instance, possible to generate multicarrier (W-) CDMA signals, to combine IS-95 and NADC or W-CDMA and DECT signals.

10.1 Generation of Multicarrier Mixed Signals with WinIQSIM

Before generating a signal of this type, the multicarrier mixed signal system has to be selected.

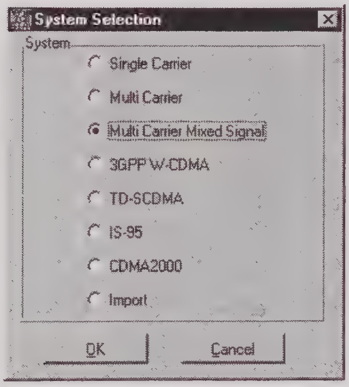


Fig. 10-1 System selection of multicarrier mixed signal

The system can be selected in the **File/New**... or **System!** menu.
The differences between the two methods are described in sections 5.22.1 and 5.23.

The block diagram of the multicarrier mixed signal system is much simpler than that of other systems and only consists of the blocks carrier settings and IF generation.

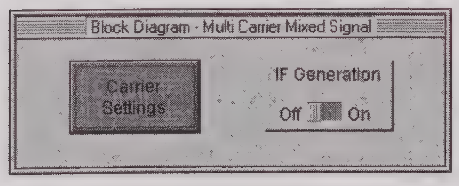


Fig. 10-2 Block diagram of multicarrier mixed signal

10.2 Status Line

The main parameters of a transmission system are displayed in a status line below the toolbar of the main panel. So the set parameters can be seen at a glance.

The status line contains icons for the different parameters; below the icons the current parameter value is indicated. The illustration below shows the status line of the multicarrier mixed signal system. The parameters pertaining to the icons are also shown in the diagram.

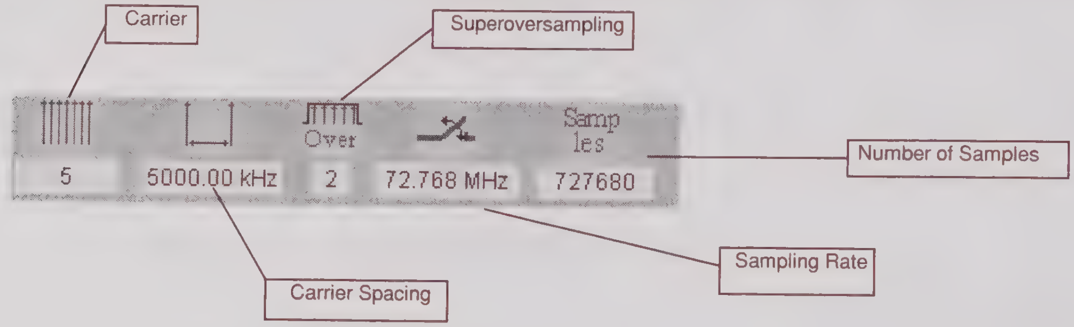


Fig. 10-3 Status line of multicarrier mixed signal

10.3 Carrier Settings Panel

The main parameters of a multicarrier mixed signal are defined in the carrier settings panel. General parameters such as carrier number and carrier spacing, and carrier-specific parameters such as power and the IQ signal to be modulated can be set in this panel. Before the panel and its control elements are described, the multicarrier system model used by WinIQSIM will be briefly outlined.

Model
A mixed multicarrier scenario with up to 32 carriers can be defined by means of WinIQSIM. An equidistant carrier spacing is assumed in this case. Any IQ signal generated with WinIQSIM can be modulated onto each carrier. These IQ signals are generated as for the add signal function in single carrier use, and saved as a file with IQ values (menu item **File: Save for Add/Multi Carrier Mixed Signal**). An IQ file of this type can be assigned to each carrier. The multicarrier signal is calculated such that a signal is built up symmetrically around the RF carrier. If an odd number of carriers is used, the central carrier is exactly on the RF carrier frequency, while with an even number of carriers, the two central carriers are positioned symmetrically at the same distance at the left and right of the RF carrier.

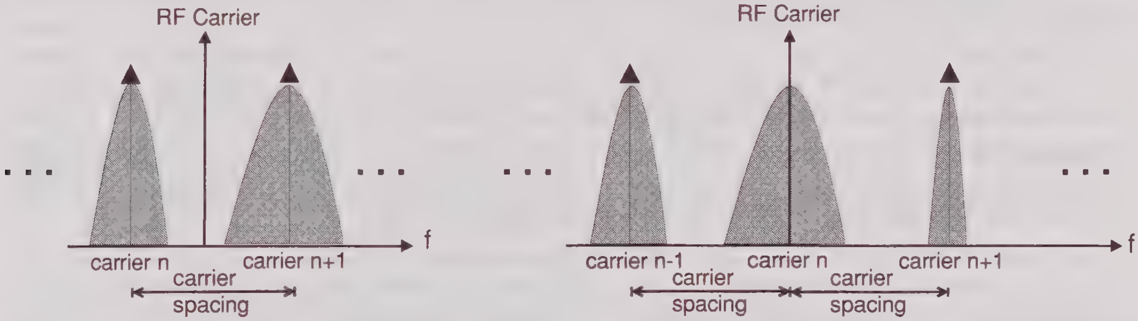
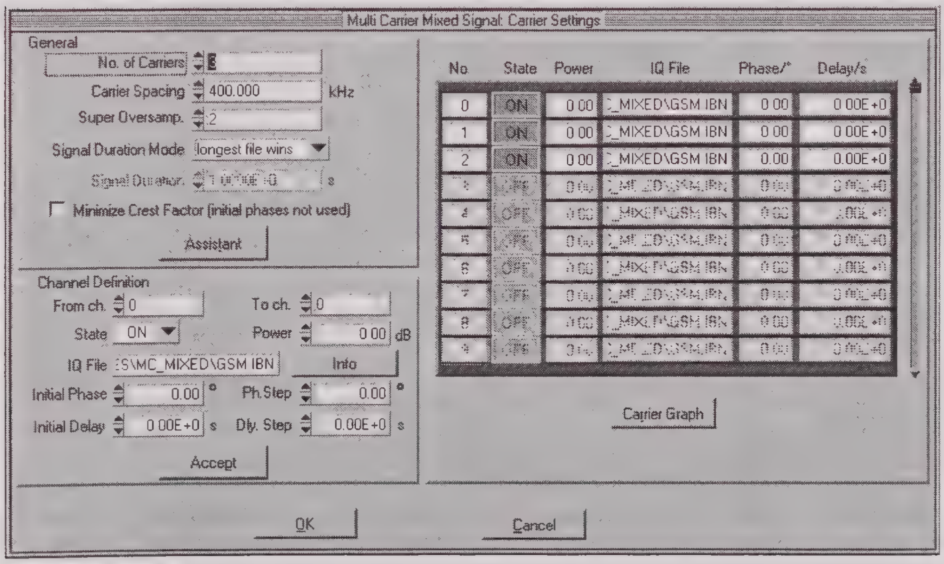


Fig. 10-4 Frequencies of single carriers (even and odd number of carriers) and their positions relative to the RF carrier

The block diagram of the multicarrier mixed signal system contains only two blocks. The IF block is described in section 5.21, IF Signal Generation. The carrier settings block is described in the following.



No. of Carriers: 3
Carrier Spacing: 400.000 kHz
Super Oversamp.: 2
Signal Duration Mode: longest file wins
Signal Duration: [illegible] s
☐ Minimize Crest Factor (initial phases not used)

From ch.: 0
To ch.: 0
State: ON
Power: 0.00 dB
IQ File: :S\MC_MIXED\GSM IBN
Initial Phase: 0.00 °
Ph.Step: 0.00 °
Initial Delay: 0.00E+0 s
Dly. Step: 0.00E+0 s

No.	State	Power	IQ File	Phase/°	Delay/s
0	ON	0.00	:_MIXED\GSM IBN	0.00	0.00E+0
1	ON	0.00	:_MIXED\GSM IBN	0.00	0.00E+0
2	ON	0.00	:_MIXED\GSM IBN	0.00	0.00E+0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	OFF	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	OFF	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	OFF	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Fig. 10-5 Carrier settings panel

General
Under General, all general carrier settings can be made. This includes the number of carriers and their frequency spacing.

Number of Carriers: In this field a number of carriers between 1 and 32 can be selected for the multicarrier mixed signal system. The carriers are consecutively numbered starting with 0. The defined carriers are entered in the scrollable table in the right-hand window of the panel. If the number of carriers is to be increased, the new entries with their fixed presettings (state: OFF, power 0 dB, most recently active IQ file, phase 0°) are added at the end of the table. If the number of carriers is reduced, the unused carriers at the end of the table are cleared.

Carrier Spacing: The frequency spacing of two adjacent carriers can be set in this field between 0 kHz to 100.000 kHz. The **Assistant** button is used to activate a panel that assists the user in setting the carrier spacing (to deal with the problem of wraparound), see section 10.3.1 in the following.

Signal Duration Mode: In this field you can determine the mode to be used for defining the resulting duration of the multicarrier mixed signal. The IQ files used in the channel table also contain information on their sampling rates and the number of IQ-value pairs. The duration of these signals can be determined with the aid of this information.

- **Longest file wins** mode: The resulting signal duration is that of the IQ file with the longest duration from the channel table. If the table contains shorter IQ files, they are continued periodically. The various sampling rates of the IQ files are adjusted automatically.
- **Shortest file wins** mode: The resulting signal duration is that of the IQ file with the shortest duration from the channel table. If the table contains longer IQ files, only the first part of those files is used. The various sampling rates of the IQ files are adjusted automatically.
- **User** mode: If this mode is selected, the field **Signal Duration** will be activated for user entries. You may now enter the desired signal duration. IQ files that are shorter than the specified duration are continued periodically, while only the first parts of too long IQ files are used. The various sampling rates of the IQ files are adjusted automatically.

Note: *If only part of an IQ signal is used or the signal is continued periodically to obtain the specified duration, problems may occur in the wraparound or in the timing of the carrier signals. This may impede the demodulation of a carrier that has been manipulated in such a way. It is therefore advisable to find a common time grid for the IQ signals when they are generated or adjust the signal duration to the IQ signal to be demodulated (in this case the remaining carriers will function as an interference scenario). If signals of only mobile radio system (eg multicarrier W-CDMA) are used, such problems will not occur.*

For determining the resulting signal duration, it is immaterial whether the carriers in the channel table are switched on or off. The determined signal duration is always that which is required when all carriers are active. This ensures that the time grid and the permitted spacing of the carrier frequencies remains constant even if one of the carriers is switched off. This is the only way in which different scenarios can be compared with some of the carriers being alternately switched on and off.

Minimize Crest Factor (initial phases not used): With this option an internal algorithm is switched on for improving the crest factor. The start phase of the individual carriers is set such that the crest factor is reduced. If the start phases of the carriers are all the same, high signal peaks may occur relative to the average signal value (demodulated value). These periodically recurring peaks occur when single carriers with the same start phase are superimposed. If the minimize crest factor option is activated, the start phases indicated in the channel table are not used and the concerned table column is dimmed.
When configuring the general parameters of the multicarrier mixed signal system, make sure that the sampling rate is not higher than the maximum clock rate of 100 MHz of AMIQ as otherwise signal calculation will not take place. The current sampling rate is always indicated in the status line of the main panel. The sampling rate increases with the number of carriers, carrier spacing and bandwidth of the set IQ files according to the following formula:

$$f_{sample} = 2 \cdot \underset{n}{MAX}\left[\left|Carrier\_Freq_n\right| + \frac{Samplerate\_IQ\_File_n}{2}\right] \cdot Superoversampling$$

The sampling rate is defined as twice the maximum frequency of the current carrier constellation and the bandwidths of the carrier signals. This sampling rate is incremented by the factor set in the superoversampling field. For determining the sampling rate, it is immaterial whether the carriers in the channel table are switched on or off. The determined sampling rate is always that which is required when all carriers are active. This ensures that the time grid and the permitted spacing of the carrier frequencies remains constant even if one of the carriers is switched off. This is the only way in which different scenarios can be compared with some of the carriers being alternately switched on and off.

Channel Definition

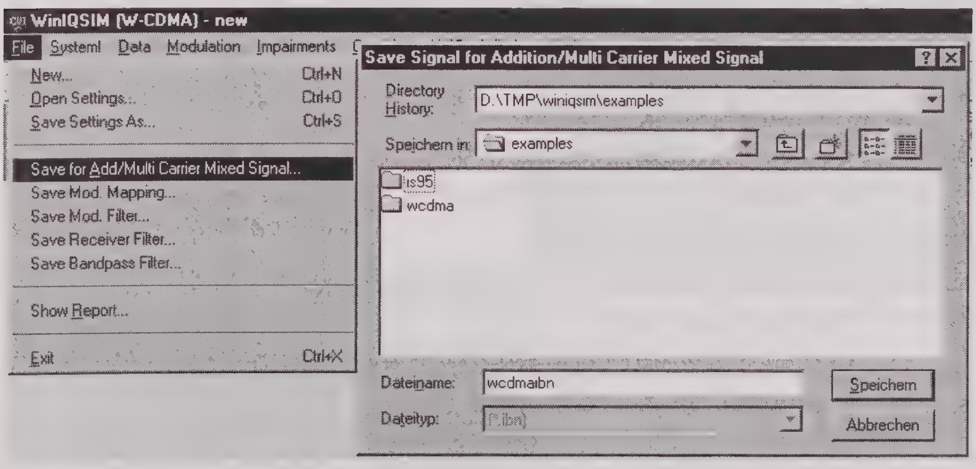
Carrier-specific parameters like power, IQ file and start phase are set in this window. The carrier range for which the parameters set in the state, power, IQ-file and initial-phase fields are valid is defined in the **From channel** and **To channel** fields. These settings are transferred to the carrier table with the **Accept** button to become effective. The possibility to configure whole ranges together considerably simplifies operation.

From/To channel: Here the range to which the subsequent parameters apply is defined. The range is always 0 to (number of carriers - 1). An ascending range (eg from 3 to 17) or a descending range (from 17 to 3) can be specified.

State: A decision can be made in this field whether the carriers in the selected range should be visible in the signal (ON) or not (OFF). By switching off some of the carriers, non-equidistant multicarrier constellations can be obtained.
The channels can also be directly switched on or off via the channel table. To do this, simply click on the state fields of the channels in the channel table.

Power: In this field, a value can be assigned to each carrier to amplify the carrier power in comparison to the others. A value in the range -80 dB to 0 dB can be set. This parameter is only effective when State is set to ON.

IQ File: This is to select the IQ signal to be modulated onto each carrier. A file-selection window is opened, from which an IQ file with the fixed extension ***.ibn** can be chosen, which contains the signal to be modulated. You can generate these IQ files in WinIQSIM for any system by calling the menu item **File: Save for Add/Multi Carrier Mixed Signal**.



Directory History: D:\TMP\winiqsim\examples

Speichern in: examples

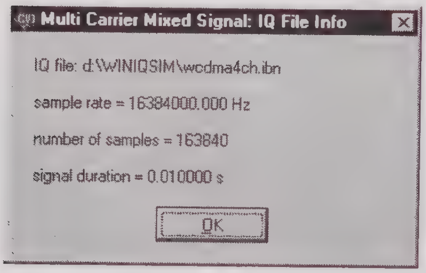
is95
wcdma

Dateiname: wcdma.ibn

Dateityp: (*.ibn)

Fig. 10-6 Saving an IQ file for modulation of a carrier

File Info button: The info button is for calling up a window containing several parameters of the selected IQ file. It shows the sampling rate, the number of samples (IQ pairs) and the signal duration of the IQ file in seconds.


Multi Carrier Mixed Signal: IQ File Info

IQ file: d:\WINIQSIM\wcdma4ch.ibn

sample rate = 16384000.000 Hz

number of samples = 163840

signal duration = 0.010000 s

Fig. 10-7 Information window for IQ file

Initial Phase: In this field you can freely select the start phase of the channel between 0° and 360°. The parameter **Phase step** serves for simple configuration of several channels with equidistant start phase. You can, for instance, generate five channels with start phases 10°, 35°, 60°, 85° and 110° by setting start channel 0, stop channel 4, initial phase 10° and phase step 25°, and then pressing the accept button. You may use the parameter start phase to generate optimized scenarios for minimizing the crest factor. If the minimize crest factor option is active, the set start phases have no effect and are shown dimmed in the table.

Initial Delay: In this field you can select a delay between –1.0 s and 1.0 s for the channel in question. The **Delay Step** parameter allows the easy configuration of several channels with equidistant delays. For example, you can generate five channels with the delays 0, 3 ns, 6 ns, 9 ns and 12 ns by selecting Start Channel 0, Stop Channel 4, Initial Delay 0 s and Delay Step 3e-9s and confirming the settings with the Accept button.

A carrier can be selected with the aid of the mouse in the table in the right-hand window of the panel. The selected carrier entry is then marked by an orange frame and is transferred to the channel definition range, where it can be readily changed.

Carrier graph: Pressing the carrier graph button opens a model panel where the defined carrier constellation is qualitatively displayed in a scrollable graph on a carrier axis.

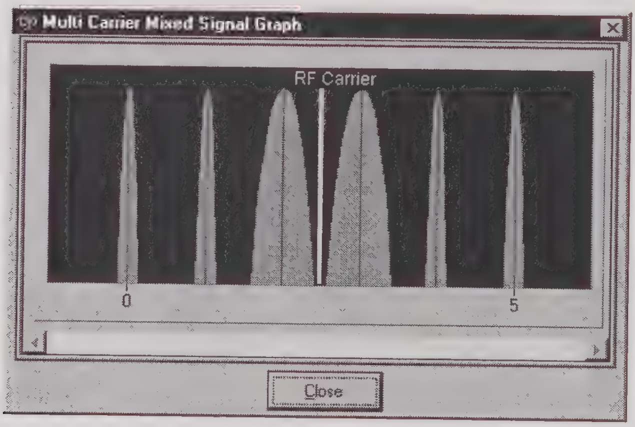


Fig. 10-8 Multicarrier mixed signal graph panel

A symbolic modulation spectrum is displayed in green around the carrier frequency for all activated carriers. The height of the modulation spectrum depends on the set carrier power. To visualize to the user the different bandwidths of the carrier signals, the width of the entered modulation spectrum is dependent of the quotient of the sampling rate of the associated IQ file and the carrier spacing. The expected signal spectrum is therefore given in the carrier graph.

The carrier graph panel can be quit with the **Close** button.

The carrier settings panel can be quit with the **OK** and **Cancel** buttons. With Cancel selected, all modifications made to the settings are discarded.

10.3.1 Assistant Function for Determining the Carrier Spacing

If a multicarrier mixed signal is to be generated, certain conditions of the baseband I/Q signals and the carrier spacing must be fulfilled to generate a clean signal. If not, there may be amplitude discontinuities causing unwanted spikes in the spectrum in particular at the wraparound point, ie the point at which the AMIQ output signal changes from the end to the start of the signal.

The time period of the baseband I/Q signal to be modulated upon the carriers must be equivalent to an integer multiple of the oscillation period with the minimum (ie closest to the RF carrier) carrier frequency. With an even number of carriers the minimum frequency spacing from the RF carrier is half the carrier spacing. The following relationship therefore applies:

$$t_{IQ-Signal} = n \cdot \frac{2}{f_{Spacing}} \qquad n \in N^{+}$$

The duration of the IQ signal is determined by the IQ files used, depending on the set **signal duration mode** (see above).

The following illustration shows a multicarrier signal with a carrier spacing which does not meet the above condition. The wraparound range is shown. In the I as well as in the Q graph, an abrupt amplitude change at the wraparound point can be seen.

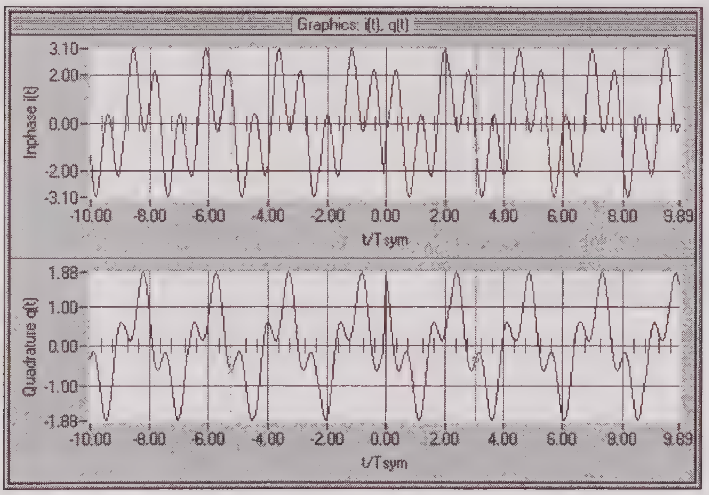
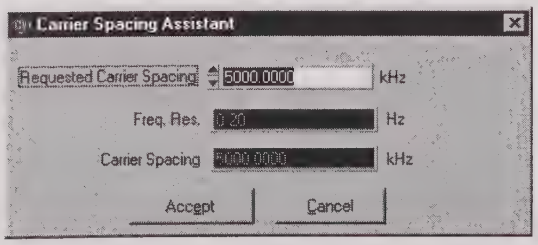


Fig. 10-9 Wraparound of a multicarrier mixed signal with carrier spacing without the use of assistant function

In order to solve the wraparound problem, the assistant function has been integrated which can be activated with the **Assistant** button in the carrier settings panel. After actuating this button, the following modal dialog window is opened:



Requested Carrier Spacing 5000.0000 kHz

Freq. Res. 0.20 Hz

Carrier Spacing 5000.0000 kHz

Fig. 10-10 Assistant function for carrier spacing

The desired carrier spacing can be entered in the **Requested Carrier Spacing** field. The resolution for varying the carrier spacing without any problems is given in the frequency resolution field. WinIQSIM automatically selects a suitable carrier spacing.
The frequency resolution is defined as

$f_{resol} = \frac{2}{signal\_duration}$, ie twice the reciprocal value of the signal duration. The longer the IQ sequence, the higher the accuracy with which a carrier spacing can be set without wraparound problems.

If the panel is closed with the **Accept All** button, all settings are accepted, whereas with the **Cancel** button all settings are discarded.

The result of setting the carrier spacing with the assistant function is shown in the figure below.

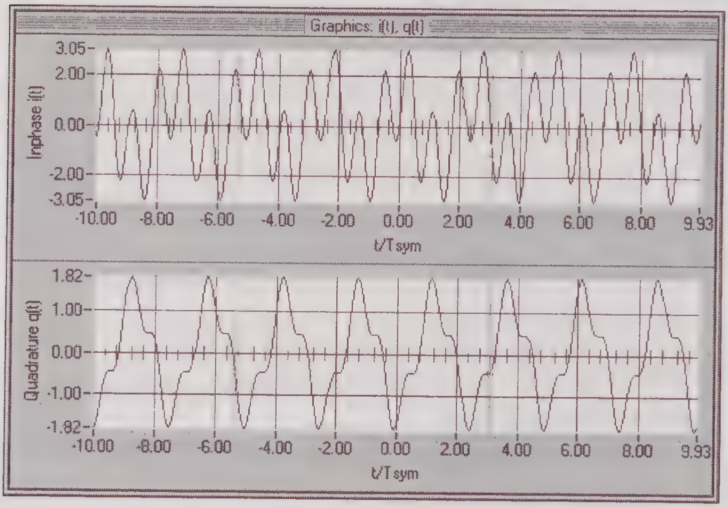


Fig. 10-11 Wraparound of a multicarrier mixed signal using carrier spacing with assistant function

10.4 Example of Generation of Multicarrier Mixed Signals

The following section contains two examples for the generation of multicarrier mixed signals. The first examples demonstrates the generation of a signal from three W-CDMA carriers with equal carrier spacing. The second example shows how the multicarrier mixed signal system can also be used for generating a mixed signal with both W-CDMA and DECT carriers.

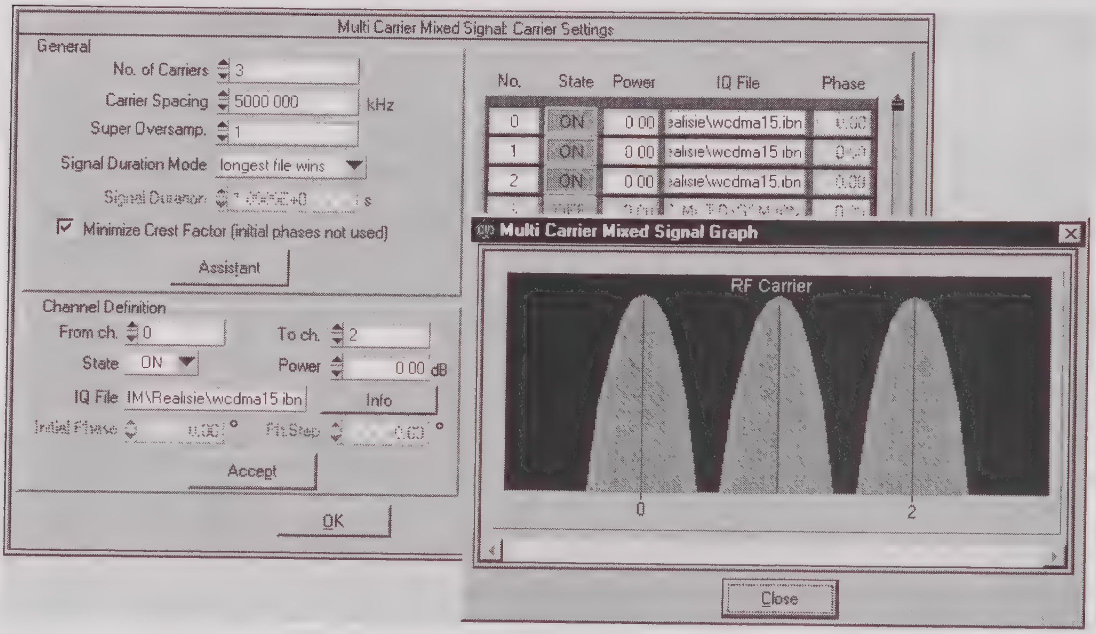
10.4.1 Generation of a Multicarrier W-CDMA Signal

To generate a signal from three W-CDMA carriers, you need to have the baseband W-CDMA signals, onto which the carriers are to be mixed. You can define any signal configurations in the W-CDMA system and save the associated IQ signals under menu item **File: Save for Add/Multi Carrier Mixed Signal**. Take care that the generated signals are of the same duration or are integer multiples of each other to avoid wraparound problems in the mixed signal.

Several files with examples on the W-CDMA system are installed with WinIQSIM. You may for instance select the configuration file **...\examples\wcdma\15dpchao.iqs** (15 dedicated channels with data offset) from (**File: Open Settings...**). The W-CDMA IQ signal is then saved as WCDMA15.ibn under menu item **File: Save for Add/Multi Carrier Mixed Signal**. For the sake of simplification, the same IQ signal is used for all carriers. Now go to the multicarrier mixed signal system (**File: New** or **System!**). Call the carrier settings panel and set the parameters as follows:

- Number of carriers: 3
- Carrier spacing: 5000 kHz
- Superoversampling: 1
- Signal duration mode: longest file wins
- Minimize crest factor: switched on
- Parameters of all carriers: state ON, power 0 dB, IQ file: ...\wcmda15.ibn

Check the set carrier spacing using the assistant function.
The carrier settings panel and the carrier graph should look as shown below.



Multi Carrier Mixed Signal: Carrier Settings

General

No. of Carriers: 3

Carrier Spacing: 5000.000 kHz

Super Oversamp.: 1

Signal Duration Mode: longest file wins

☑ Minimize Crest Factor (initial phases not used)

No.	State	Power	IQ File	Phase
0	ON	0.00	ealisie\wcdma15.ibn	[illegible]
1	ON	0.00	ealisie\wcdma15.ibn	[illegible]
2	ON	0.00	ealisie\wcdma15.ibn	0.00

Channel Definition

From ch.: 0 To ch.: 2

State: ON Power: 0.00 dB

IQ File: IM\Realisie\wcdma15.ibn

Fig. 10-12 Carrier settings panel for a multicarrier W-CDMA signal

Call the graphics panel (format FFT magnitude, window Hanning, AVG auto, autoscale, freq/time spacing). The multicarrier W-CDMA signal is now computed and the following signal spectrum is displayed.

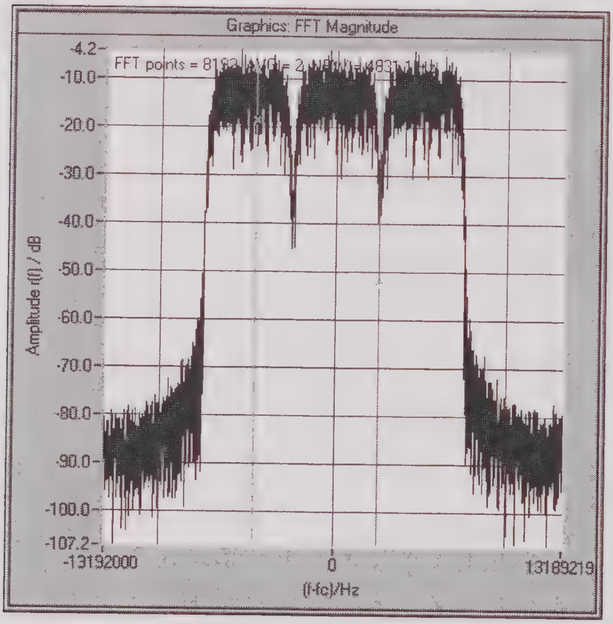


Fig. 10-13 Spectrum of multicarrier W-CDMA signal

Save the IQ signal of this multicarrier scenario as MC_WCDMA.ibn via menu item **File: Save for Add/Multi Carrier Mixed Signal**. This signal will be required for the following example.

10.4.2 Generation of a Multicarrier Signal from DECT and W-CDMA Carriers

This example demonstrates the generation of a multicarrier scenario with DECT and W-CDMA signals with different carrier spacings. The signal to be generated basically looks as follows:

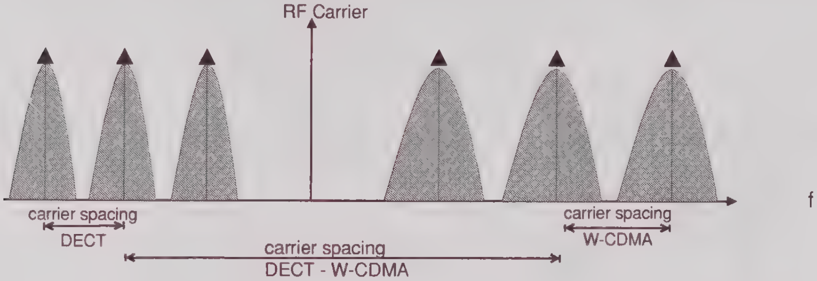


Fig. 10-14 Scenario of a mixed signal from DECT and W-CDMA carriers

The carrier spacing between the W-CDMA signals should be 5 MHz, the spacing between the DECT signals 1.728 MHz (as prescribed by the relevant standards).

To generate a signal of this type, a DECT baseband signal has first to be calculated. This is done as described in the above example for the W-CDMA baseband signal (loading the example file **...\examples\dect_sl0.iqs**, computing and saving the IQ signal as dect.ibn via **File: Save for Add/Multi Carrier Mixed Signal**). Go to the multicarrier mixed signal system and make the following settings:

- Number of carriers: 3
- Carrier spacing 1728 kHz
- Superoversampling: 1
- Signal duration mode: longest file wins
- Minimize crest factor: switched on
- Parameters of all carriers: state ON, power 0 dB, IQ file: ...\dect.ibn

Check the set carrier spacing using the assistant function.

Look at the signal spectrum in the diagram and save the multicarrier DECT signal as MC_DECT.ibn under **File: Save for Add/Multi Carrier Mixed Signal** .

The mixed signal scenario is now put together from the two computed multicarrier IQ signals for DECT and W-CDMA. To do this, set the following parameter in the multicarrier mixed signal system:

- Number of carriers: 2
- Carrier spacing: 20,000 kHz
- Superoversampling: 1
- Signal duration mode: longest file wins
- Minimize crest factor: switched on
- Parameters of carrier 0: state ON, power 0 dB, IQ file: ...\MC_DECT.ibn
- Parameters of carrier 1: state ON, power 0 dB, IQ file: ...\MC_WCDMA.ibn

Check the set carrier spacing using the assistant function.

The duration of the W-CDMA mixed signal is 20 ms (IQ file info button shows this value), while that of the DECT mixed signal is 10 ms. As the option longest file wins is selected, the DECT signal is extended periodically to twice its duration. If there is no wraparound problem in the original DECT signal, the extended signal will also have a smooth transition between signal end and beginning. If in contrast the option shortest file wins were selected, the DECT portion of the signal would not have any wraparound problems either. The W-CDMA portion adjusted to a signal duration of 10 ms, on the other hand, would with high probability show amplitude discontinuities at the wraparound points (appearing as undesirable spikes in the spectrum).

Finally, let us take a look at the spectrum of the mixed signal shown in the diagram.

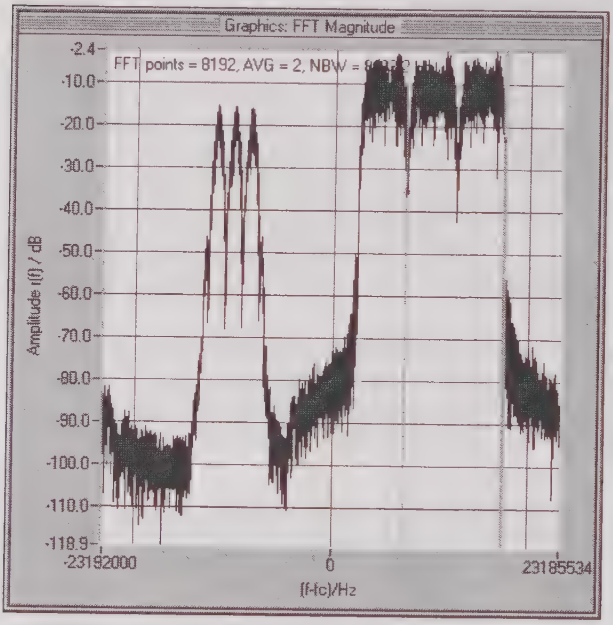


Fig. 10-15 Spectrum of a mixed signal from DECT and W-CDMA carriers

Through the multiple use of the multicarrier mixed signal system, you can also easily generate mixed signals with different carrier spacings or multi-multicarrier signals.

11 Import System

The import system makes it possible to extend WinIQSIM by user-specific systems.
A second program running at the same time as WinIQSIM transfers the waveform (unprocessed signal) to WinIQSIM. In WinIQSIM, the signal undergoes all known processing stages from filtering to signal transfer to AMIQ. So, all the user has to do is generate the (unfiltered) waveform. All other functions such as filtering, superposition of impairments, graphics display and control of AMIQ/SMIQB60 are provided by WinIQSIM.

Note: *The import system is a general system not limited to the generation of baseband signals. For example, it allows AMIQ to be used as a general-purpose dual-channel arbitrary waveform generator for the output of any types of waveform (e.g. audio or video).*

11.1 Configuration of Import Interface

Communication between WinIQSIM and an application is via an import interface. The latter may be implemented either as standard Windows DDE (Dynamic Data Exchange) or as TCP/IP interface.

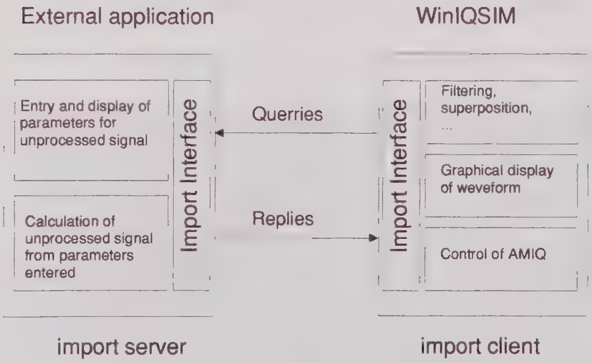

External application
WinIQSIM
Entry and display of parameters for unprocessed signal
Calculation of unprocessed signal from parameters entered
Import Interface
Querries
Replies
Import Interface
Filtering, superposition, ...
Graphical display of weveform
Control of AMIQ
import server
import client

Fig. 11-1 Division of tasks between external application and WinIQSIM

The external application is used as a server for the data and is referred to as "import server" in the following. In certain operating states, WinIQSIM outputs queries to the data server to which the import server replies. The following queries are defined:

- Server identity
- Parameter status
- Sequence length
- Symbol rate
- Waveform

The DDE interface is described in detail in section 11.2.

The DDE interface is widely used since it was available with earlier Windows versions. It is very fast and is available with every Windows system. DDE is supported by almost all development systems but is in some aspects rather involved.

The communication between server and client can be described by means of the parameters *ServerName*, *TopicName* and *ItemName* that are all constant with WinIQSIM.

IMPORTANT: *The DDE interface works reliably only under WindowsNT/2000.*
Under Windows95/98, use the ***TCP/IP interface only !***

The TCP/IP interface is older than the DDE interface but is preferred for communication between processors. To be able to use this interface the TCP/IP driver must be installed on the PC. This is the case if for example the processor has a connection to a LAN or to the Internet.
The advantage of the TCP/IP link is that the server can run on other processors as WinIQSIM and use any operating system, e.g. LINUX.
TCP/IP is supported by all known development systems.
The communication between server and client can be described by means of the parameters *ServerName* (=IP Address) and *PortNumber.*

A detailed description of the import interface is described in section 11.3

11.2 Operation of Import System under WinIQSIM

To generate a signal from the import system, the import system itself must first be selected.

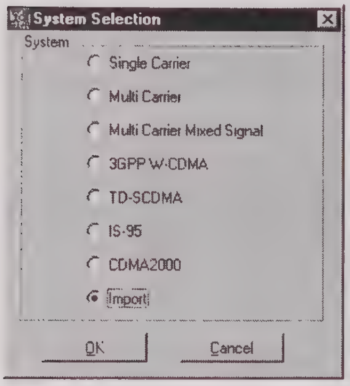


Fig. 11-2 Selection of import system

System selection is accessible from the **File/New**... or **System!** menu.
The differences between the two methods are described in sections 5.22.1 and 5.23.

The import block diagram is based on that of the single carrier system.

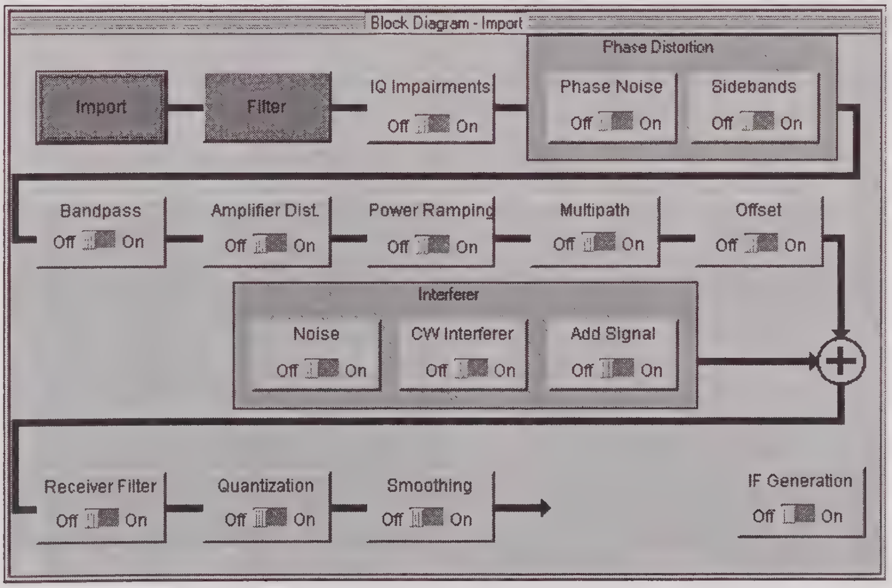


Fig. 11-3 Import block diagram

The "IQ Impairments", "Phase Noise", ... "IF Generation" blocks are identical. Data and modulation are supplied by the import server. The two associated blocks ("Data Source" and "Modulation Settings") have therefore been replaced by two new blocks:

- Import: Display and setting of characteristics of import link
- Filter: Setting of filtering parameters

11.2.1 Status Line

The main parameters of a transmission system are displayed in a status line below the tool bar of the main panel. The set parameters can thus be seen at a glance.

The status line contains icons for the different parameters; below the icons the current parameter values are indicated. The illustration below shows the status line of the import system with the parameters assigned to the icons.

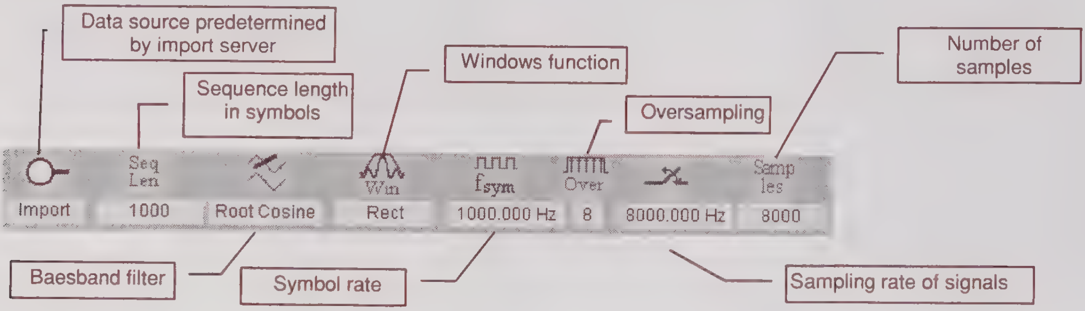


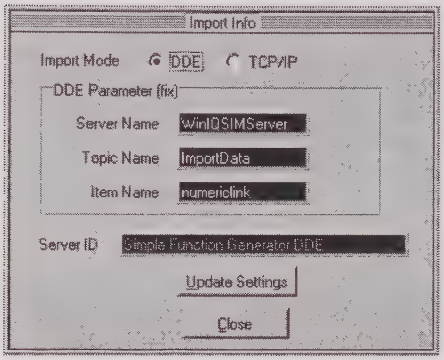
Fig. 11-4 Import status line

11.2.2 Import Panel

The import panel shows the interface parameters and the name of the currently connected import server.

The mode matching the import server can first be selected here.

If the DDE is selected, the following panel is displayed:


Import Mode ● DDE ○ TCP/IP

DDE Parameter (fix)

Server Name: WinIQSIMServer

Topic Name: ImportData

Item Name: numericlink

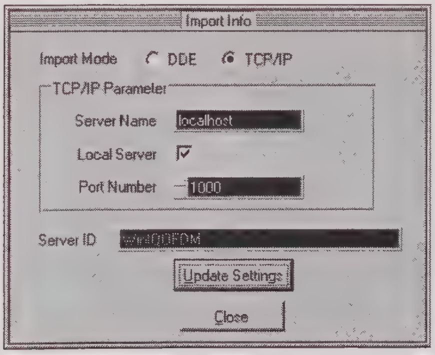
Server ID: Simple Function Generator DDE

Fig. 11-5 Import panel (DDE)

IMPORTANT: *The DDE interface works reliably only under WindowsNT/2000.*
Under Windows95/98, use the ***TCP/IP interface only !***

The parameters shown in the upper half of the panel are static ones and described in greater detail in section 11.3.1.1.11.3.1.1.

The displayed panel in the TCP/IP mode is as follows:


Import Mode ○ DDE ● TCP/IP

TCP/IP Parameter

Server Name: localhost

Local Server: ☑

Port Number: 1000

Server ID: WinIQOFDM

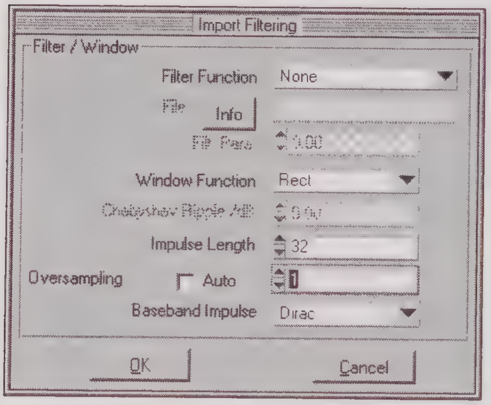
Fig. 11-6 Import Panel (TCP/IP)

The server name is the IP address of the connected server, e.g. "12.34.56.79". If the servers runs on the same processor as WinIQSIM, the text "localhost" can be entered for the server name. This is entered automatically when the local server switch is checked. The port number matching the server is selected in the third field.

Under "Server ID", the identification of the connected import server is indicated. If "not connected" is displayed in the field, then there is no import server connected. Pressing the "Update Settings" button will start a search for an import server. If a server is found, its identity is displayed.
The panel can be exited with "Close".

11.2.3 Filtering

The data supplied by the import server are first subjected to baseband filtering.



Import Filtering

Filter / Window

Filter Function: None

Window Function: Rect

Impulse Length: 32

Oversampling ☐ Auto: 1

Baseband Impulse: Dirac

Fig. 11-7 Import Filtering

The setting options are identical to those of the single carrier system and are described there (5.8).

If the waveform has undergone filtering in the import server before, WinIQSIM filtering can be skipped. This is done by selecting filter function "None" and Oversampling "1".
If the sampling rate is to be increased without additional pulse shaping, the filter type "Ideal Lowpass" should be selected.
This filter has a very steep frequency response so the maximum pulse length is to be selected.

11.3 Description of Import Interface

11.3.1 Description of DDE Import Interface

The explanations given below are valid for programming under National Instruments LabWindows CVI 5.0. In other development environments, similar commands are used for the most part. Please refer to the manuals for your development environment to get familiar with programming of the DDE interface.

The DDE system consists of a server and one or several clients.
Here, the server is the passive part supplying data and responding to queries from the client.
The client is the active part which initiates communication.
Although communication the other way round is also possible, WinIQSIM is operated as a client and the external application as a server in this case. A so-called "hotlink" is established for the server to transfer data to the client.

11.3.1.1 Server Name, Topics and Items

A common name must be defined for the server so that the server and the client can establish a link with each other. The name in this case is "**WinIQSIMServer**".

Since a server can provide several services (referred to as topics), a topic has to be agreed under the server name. The topic for the complete communication between WinIQSIM and the import servers is "**ImportData**".

Within a topic, several subservices ("items") are defined. In the case of WinIQSIM, these are:

Table 11-1 DDE items

Item	Direction	Meaning
GetServerID	WinIQSIM->Import Server	ID query
GetNewState	WinIQSIM-> Import Server	Query if new data are available
GetSequenceLength	WinIQSIM-> Import Server	Query of sequence length
GetSymbolRate	WinIQSIM-> Import Server	Query of symbol/reference point rate in Hz
GetSymbols	WinIQSIM-> Import Server	Query of number of symbols/reference points
Numericlink	Data Server->WinIQSIM	Response to query

11.3.1.2 Format of Query Commands

Since no parameters need to be included in the query commands, they are sent with *ClientDDEExecute()*.
The item name is added to this function as a parameter, for example:
ClientDDEExecute (huConvClient, "GetNewState", 0);
"huConvClient" is the handle of the DDE link and "0" the timeout value.

11.3.1.3 Format of Replies (Messages) from Import Server

Replies are returned with *AdviseDDEDataReady().*

Note: *The reply must get to WinIQSIM within 10 seconds, since otherwise timeout occurs. If the calculation (including transmission) lasts a long time, it must not be triggered by a query. The server must have a data set in reserve which it returns as a response to "GetSymbols".*

Only one hotlink (item "numericlink") is established. To distinguish between replies to different queries, a header is placed in front of the data section of the reply:

```
typedef enum { SYMBOLRATE, SEQUENCE_LENGTH, SYMBOLS, NEWSTATE, SERVER_ID }
SERVER_MESSAGE_HEADER_TYPE;

typedef struct
{
      SERVER_MESSAGE_HEADER_TYPE type;
      float data;
}
SERVER_MESSAGE_TYPE;

SERVER_MESSAGE_TYPE Reply;

Reply.type = SEQUENCE_LENGTH;
Reply.data = (float)SequenceLength;
AdviseDDEDataReady (huConvServer, "numericlink", CF_TEXT,
&Reply,sizeof(Reply), 0);
```

ServerID, NewState and symbol rate are treated like the sequence length. In order to transmit the symbol values to WinIQSIM, above structure cannot be used, since the message is longer than 1 float value. A free memory area must be filled then with data as follows:

Pos 1 : SYMBOLS (enum, = 2)
Pos 2 : I(0)
Pos 3 : Q(0)
Pos 4 : I(1)
Pos 5 : Q(1)
....
*Pos 2*N : I(N-1)*
*Pos 2*N+1 : Q(N-1)*

A pointer on this block will then be transferred to the function AdviseDDEDataReady().

Note: *Alternatively to transmitting the waveform in one block, the samples can be divided among several blocks. In the latter case, only the first block is sent with a header, the following blocks are without header. I/Q samples forming a pair must not be divided among different blocks.*

11.3.2 Description of TCP/IP Import Interface

The following sections apply to programming under National Instruments LabWindows CVI 5.0. The commands have a similar designations in other development environments. Please consult the manuals of the required development environment to familiarize yourself with programming the TCP/IP.

A TCP/IP link consists of a server and one or several clients.
The server gets the data ready and transfers them to the client on request or spontaneously. The client takes the incoming data.

WinIQSIM is considered here as client and the external application as server, although the other solution would also be possible.

11.3.2.1 Server Name, Port Number and Items

To build up a link to the server, the client must know the name of the server (e.g. 12.34.56.78). Also the parties must agree on a common channel, the so-called port. The default value is 1000 but any other value may be chosen. Some ports are pre-allocated (e.g. 80 for Browser) and are to be avoided.

Communications are exchanged between client and server. Communications from client and server are ASCII strings (analogous to DDE mode), messages from the server are in the form of binary blocks with a format such as in the DDE mode.

Table 11-2 TCP/IP items from client to server

Item	Meaning
GetServerID	ID query
GetNewState	Query if new data are available
GetSequenceLength	Query of sequence length
GetSymbolRate	Query of symbol/reference point rate in Hz
GetSymbols	Query of symbols/reference points

11.3.2.2 Format of Query Commands

Query commands are sent with *ClientTCPWrite (gHandle, request, strlen(request), 1000)*; the last parameter timeout is given in ms.

11.3.2.3 Format of Replies (Messages) of Import Server

Replies are sent with *ServerTCPWrite ()*.

Note: *The reply must get to WinIQSIM within 10 seconds, since otherwise timeout occurs. If the calculation (including transmission) lasts a long time, it must not be triggered by a query. The server must have a data set in reserve which it returns as a response to "GetSymbols".*

To distinguish between replies to different queries, a header is placed in front of the data section of the reply:

```
typedef enum { SYMBOLRATE, SEQUENCE_LENGTH, SYMBOLS, NEWSTATE, SERVER_ID }
SERVER_MESSAGE_HEADER_TYPE;

typedef struct
{
      SERVER_MESSAGE_HEADER_TYPE type;
      float data;
}
SERVER_MESSAGE_TYPE;

SERVER_MESSAGE_TYPE Reply;

Reply.type = SEQUENCE_LENGTH;
Reply.data = (float)SequenceLength;
ServerTCPWrite (gHandle, (void *)&Reply, sizeof(Reply), 1000);
```

ServerID, NewState and the symbol rate are handled the same way as the sequence length.
The above format cannot be used if the symbol value is to be sent to the WinIQSIM because the message is more than 1 float value long.
A free memory block must be filled then with data as follows:

Pos 1 : SYMBOLS (enum, = 2)
Pos 2 : I(0)
Pos 3 : Q(0)
Pos 4 : I(1)
Pos 5 : Q(1)
....
*Pos 2*N : I(N-1)*
*Pos 2*N+1 : Q(N-1)*

A pointer on this block will then be transferred to the function ServerTCPWrite().

Note: *Alternatively to transmitting the waveform in one block, the samples can be divided among several blocks. In the latter case, only the first block is sent with a header, the following blocks are without header.*

11.4 User-Generated Import Applications

As mentioned above, all information given here refers for the time being to the LabWindows CVI 5.0 development environment.

During the installation of WinIQSIM, the subdirectory "DDEServerExample" is created which demonstrates programming of an import data server using the example of a simple function generator.

11.4.1 ImportIFDrv Module

The two files ImportIFDrv.c and ImportIFDrv.h also belong to the project "Function Generator" and can be easily used for import applications.

This module greatly simplifies the creation of import applications:

- detailed knowledge about the import interface not required (e.g. dynamic procedures)
- simple switchover between DDE and TCPIP without changing the user code
- simple function interface
- ImportIFDrv.c./.h are continuously updated. Imported applications, therefore, directly benefit from error removal, software optimization and the introduction of new protocols or interfaces.

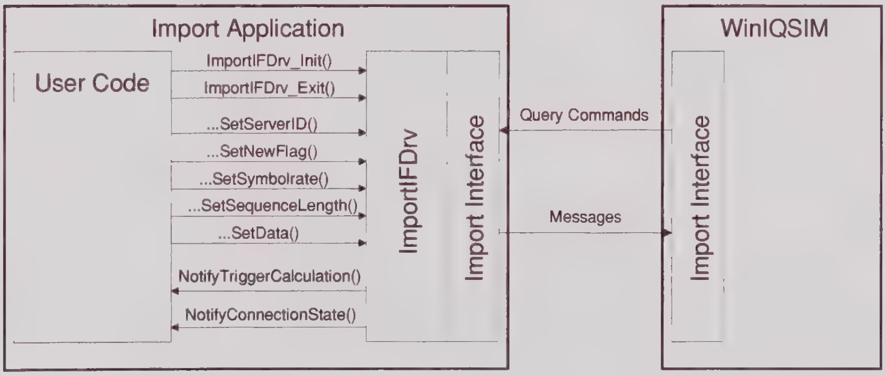


Fig. 11-8 Use of the module ImportIFDrv for import application

The two functions must be called at the start and end of the import application:

- void ImportIFDrv_Init (IMPORT_METHOD_TYPE import_method)
- void ImportIFDrv_Exit(void)

The user must inform the ImportIFDrv module about changes in values via the following functions:

- void ImportIFDrv_SetServerID(const char *server_id)
- void ImportIFDrv_SetNewFlag(void)
- void ImportIFDrv_SetSymbolrate(float symbol_rate)
- void ImportIFDrv_SetSequenceLength(float sequence_length)
- void ImportIFDrv_SetData(float *samples)

In addition, the two functions

- void NotifyTriggerCalculation(void)
- void NotifyConnectionState(int nConnected)

must be implemented in the user code. ImportIFDrv module can signal specific states via the functions:

NotifyTriggerCalculation()
WinIQSIM requests the current trace. User code must now ensure that KernelIFDrv has a valid pointer on the current data, i.e. transfer of pointer per ImportIF_SetData(), if necessary.
If there is no valid data set, it may prior be calculated provided the total reaction time of 10 seconds to the WinIQSIM query is not exceeded.
This method can be used for example in the program example function generator.
With longer calculations the results must be available before NotifyTriggerCalculation(). In this case, the calculation must be initiated through an event (e.g. "Calculate" button). A dummy data set must be kept as long as the results are not ready.

NotifyConnectionState(int nConnected)
This message serves for informing the user code whether a link is being set up (nConnected = 1) or cleared down (nConnected = 0). This information can be utilized to show the status of a link.

12 CDMA2000

WinIQSIM can also generate CDMA2000 signals. Section 12.1 gives an overview of this mobile radio transmission method. Section 12.2 describes the associated control functions. Section 12.3 provides in-depth information about the generation of CDMA2000 signals.

12.1 Description of Mobile Radio Transmission Method CDMA2000

CDMA2000 is the North American standard for the third mobile radio generation (3G). It uses two different chip rates, the so-called spreading rates. The 1X mode is specified with a chip/spreading rate of 1.2288 Mcps and the 3X mode three times this rate, ie 3.6864 Mcps. In addition to the direct-spread method known from FDD (frequency division duplex) of W-CDMA, the multicarrier mode is also defined for CDMA2000. The multicarrier mode is one of the three modes proposed by the Operators Harmonization Group (OHG) for a global standard of the third mobile radio generation.

CDMA2000 is a further development of the North American mobile radio system of the second generation IS-95 (CDMA). A brief description of the development of IS-95 to CDMA2000 is given in the following.

Development of IS-95 to CDMA2000

IS-95A is the original version of IS-95 (also known as J-STD-008). This standard uses only a few channel types (pilot, paging, traffic and sync in the forward link, access and traffic in the reverse link) with not more than one traffic channel (9.6 or 14.4 kbps) between base station (BS) and mobile station (MS). The modulation in each channel prior to spreading is BPSK in the forward link and 64ary orthogonal in the reverse link at the chip rate of 1.2288 Mcps.
This basic implementation stage has been realized in WinIQSIM (system IS-95) for a long time.

IS-95B is an extension increasing the data rate to up to 64 kbps through channel bundling (max. 8 traffic channels). A few new channel types are introduced (eg quick paging, broadcast, enhanced access and reverse pilot channel) to implement improvements (handoff, access channel). The IS-95B operating modes are still used in the radio configurations 1 and 2 of CDMA2000 (in both directions).

IS-95C retains the 1.2288 Mcps chip rate but uses a modern spreading technique (variable spreading factors, distribution of bits to I and Q path (QPSK)).
The rate can be further increased by a factor of two. IS-95C is also called 'Phase 1' of CDMA2000. All radio configurations besides RC1 and RC2 using the 1X spreading rate (ie 1.2288 Mcps) correspond to the IS-95C modes.

CDMA2000 is the North American candidate for a worldwide W-CDMA system to be defined by ITU. Besides 'Phase 1' of IS-95C, higher chip rates (3X, 6X, 9X and 12X) are defined for 'Phase 2'. Modern techniques (eg transmit diversity, turbo codes and extended spreading codes) are introduced. The TIA interim standard IS2000, which is the basis for the CDMA2000 system used in WinIQSIM, was derived from the proposal to the ITU. Analogously to 3GPP, the high chip rates (6X to 12X) are no longer of importance and therefore not considered in this standard.

IS-95 HDR (high data rate) is an extension of IS-95B/C which dramatically increases the available data rate (to max. 2.5 Mbps) among other things by an additional carrier (2X).
This mode is an offshoot of the CDMA development and not included in CDMA2000.

cdmaOne is a trademark of the CDMA Development Group (CDG) that can be used by all members of CDG for their products. It is a generic term for the first generation of CDMA IS-95A and the extension IS-95B.

The current version of WinIQSIM (as of version 3.20) supports CDMA2000 according to the version of July 1999 defined in the IS-2000 standard (see References).

References:

[1] TR45 Introduction to cdma2000 Standards for Spread Spectrum Systems (PN-4427, to be published as TIA/EIA/IS-2000-1), Ballot Resolution Version, July, 1999
[2] TR45 Physical Layer Standard for cdma2000 Spread Spectrum Systems (PN-4428, to be published as IS-2000-2), July, 1999

WinIQSIM simulates CDMA2000 signals at the physical channel level including channel coding. The following description is therefore limited to this layer.

The table below gives an overview of the main parameter of the CDMA2000 system in WinIQSIM.

Table 12-1 Parameters of CDMA2000

Chip rates / Spreading rate	1X (1.2288 Mcps) und 3X (3.6864 Mcps)
Mode	Multicarrier and direct spread
Radio configuration	RC 1 – RC 9
Channel types of forward link (depending on radio configuration)	Forward Pilot Channel (F-PICH) Forward Synchronisation Channel (F-SYNC) Forward Paging Channel (F-PCH) Forward Transmit Diversity Pilot Channel (F-TDPICH) Forward Auxiliary Pilot Channel (F-APICH) Forward Auxiliary Transmit Diversity Pilot Channel (F-ATDPCH) Forward Broadcast Channel (F-BCH) Forward Quick Paging Channel (F-QPCH) Forward Common Power Control Channel (F-CPCCH) Forward Common Assignment Channel (F-CACH) Forward Common Control Channel (F-CCCH) Forward Dedicated Control Channel (F-DCCH) Forward Fundamental Channel (F-FCH) Forward Supplemental Channel (F-SCH)
Channel types, reverse link	Reverse Pilot Channel (R-PICH) Reverse Access Channel (R-ACH) Reverse Enhanced Access Channel (R-EACH) Reverse Common Control Channel (R-CCCH) Reverse Dedicated Control Channel (R-DCCH) Reverse Fundamental Channel (R-FCH) Reverse Supplemental Code Channel (R-SCCH) Reverse Supplemental 1 Channel (R-S1CH) Reverse Supplemental 2 Channel (R-S2CH)
Symbol rates	1.2 kbps; 1.35 kbps; 1.5 kbps; 1.8 kbps; 2.4 kbps; 2.7 kbps; 3.6 kbps; 4.8 kbps; 7.2 kbps; 9.6 kbps; 14.4 kbps; 19.2 kbps; 28.8 kbps; 38.4 kbps; 57.6 kbps; 76.8 kbps; 115.2 kbps; 153.6 kbps; 230.4 kbps; 259.2 kbps; 307.2 kbps; 460.8 kbps; 518.4 kbps; 614.4 kbps; 1036.8 kbps depending on radio configuration and channel type
Number of channels	4 base-station or mobile-station channels, each with up to 91 or 13 code channels, depending on the link direction
PN offset	0 - 511
Quasi-orthogonal Walsh sets	Set 1 to set 3
Channel coding	Modes: off, complete, without interleaving, interleaving only
Long-code mask	0 to 3FF FFFF FFFF
Spreading codes	Variable-length Walsh codes

12.1.1 System Components

The system configuration of CDMA2000 in the forward and reverse link is shown in Fig. 12-2 below. This simplified diagram is used to explain the system principle. The exact system configuration depends on parameters like link direction, spreading rate, mode, radio configuration and channel type. A detailed description cannot be given in this manual. For further information refer to the IS2000 standard (see [2]).

12.1.1.1 Forward Link

The following block diagram illustrates generation of a code channel for the forward link of CDMA2000.

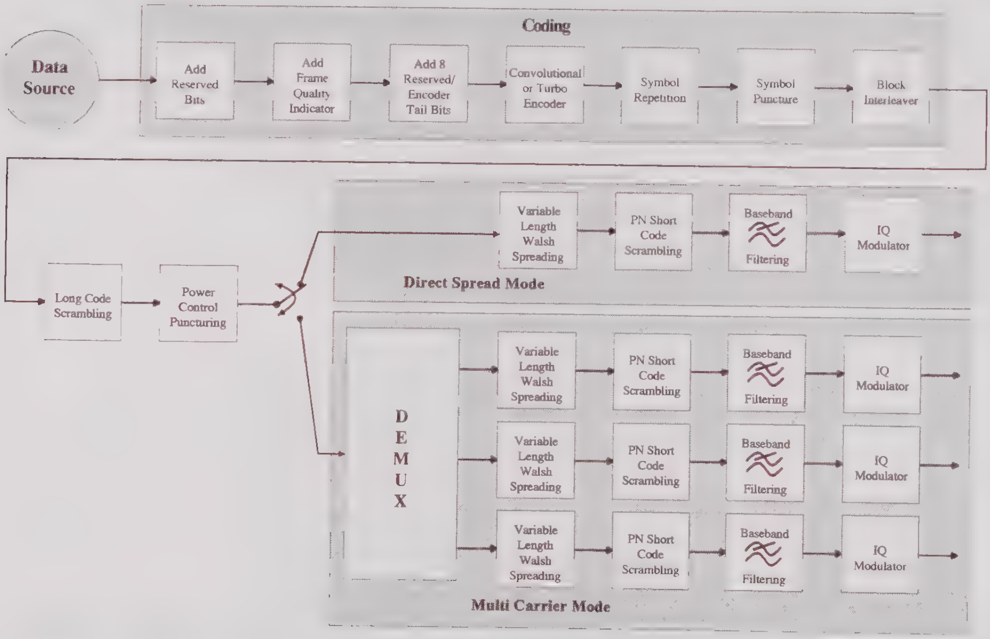


Fig. 12-1 Components of CDMA2000 transmission system in the forward link

The individual functional blocks are:

Data Source
The data source used in WinIQSIM is implemented at the physical layer prior to channel coding. Channel coding of the physical layer as defined by CDMA2000 is implemented in WinIQSIM (see below). Logic channels are not assigned to the physical channel layer. If the data source is to be implemented at a higher layer, this can be done with the aid of a file interface (see section 5.6).

Channel coding
In contrast to W-CDMA, channel coding with CDMA2000 is part of the physical layer. The channel coding prodecure may slightly vary depending on channel type, frame length and data rate. The basic coding procedure is illustrated by the coding block in the diagram above. Blocks like 'Add reserved bits' or 'Symbol puncture' are not used in all coding scenarios. For a more exact definition refer to the standard [2].

- **Add reserved bits**: areas reserved for future applications are filled with 0 bits.
- **Add frame quality indicator**: calculation and insertion of a CRC (cyclic redundancy code) checksum for error identification.
- **Add 8 reserved/encoder tail bits**: reserved areas for future applications or fixed data sequences are added to a data block to set the subsequent coder to a defined final state.
- **Convolutional or turbo encoder**: error correction code, depending on data rate and other parameters either by convolutional coding or turbo codes.
- **Symbol repetition**: symbol repetition is used together with bock symbol pucture for adapting the convolutional or turbo coder output data rate to the required input data rate of the interleaver.
- **Symbol puncture**: symbol puncturing (elimination) is used together with bock symbol repetition for adapting the convolutional or turbo coder output data rate to the required input data rate of the interleaver.
- **Block interleaver**: blockwise permutation of input data sequence of interleaver to avoid block errors.

Long-code scrambling

The long-code generator is also referred to as scrambling code generator since it scrambles the chip sequence in a user-specific way (long-code mask).

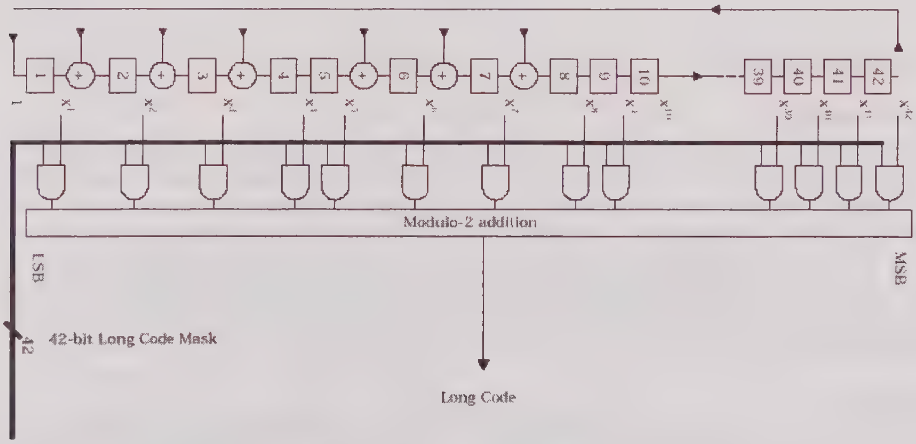


Fig. 12-2 Long-code generator CDMA2000

The long-code generator is a feedback 42-bit shift register with its status vector linked to a user-specific long-code mask to form the specific long-code sequence.

The generator polynomial of the shift-register section of the long-code generator is:

$$p(x) = x^{42}+x^{35}+x^{33}+x^{31}+x^{27}+x^{26}+x^{25}+x^{22}+x^{21}+x^{19}+x^{18}+x^{17}+x^{16}+x^{10}+x^{7}+x^{6}+x^{5}+x^{3}+x^{2}+x^{1}+1$$

When a spreading rate (chip rate) 1X (1.2288 MHz) is used, the long-code generator is used as described above. With the spreading rate 3X (3.6864 MHz), a long-code sequence with a three-fold clock is required. To this end the long-code generator described above is used as shown in the diagram below.

A real long code is used in the forward link. In the reverse link a complex long code with I and Q component is required. The long code for the I component is derived directly from the 1X or 3X generator, that for the Q component corresponds to the I long code delayed by one chip.

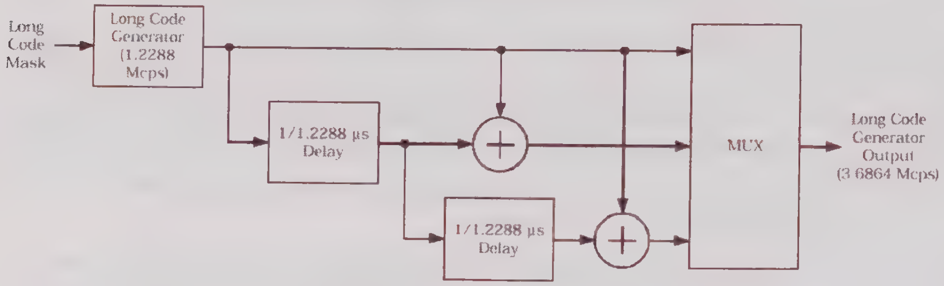

Long Code Mask
Long Code Generator (1.2288 Mcps)
1/1.2288 µs Delay
1/1.2288 µs Delay
MUX
Long Code Generator Output (3.6864 Mcps)

Fig. 12-3 Long-code generator for spreading rate 3X

Power control puncturing
To control the output power of the mobile station, the base station sends power control bits in the traffic channal at an 800 Hz rate instead of the scrambled data bits. Depending on the power control bits, the mobile station increases or reduces its output power.

The further sequence of signal generation depends on whether the direct-spread mode or the multicarrier mode is used.

12.1.1.1.1 Direct Spread Mode

Variable-length Walsh spreading
Spreading of the CDMA2000 signal is performed in this block. Walsh codes with a variable spreading factor are used. The spreading factor and the Walsh code depend on the spreading rate, channel type, frame length and data rate. To extend the base-station capacity, so-called 'quasi-orthogonal Walsh sets' can be used in addition to the Walsh codes. The input data stream of the spreading unit is already complex (I + jQ). If a standard Walsh code is used, spreading is performed by multiplying the input symbol (modulo 2 multiplication) with the real Walsh code. The quasi-orthogonal Walsh code results in complex spreading through an additional rotation of the output phase (the spreading code then consists of a real and an imaginary part).

PN short-code scrambling
The (complex) input data stream of the PN short-code scrambler is multiplied by a complex PN sequence (I_{PN} + j Q_{PN}). This is also called 'quadrature spreading'. With channels of the radio configurations 1 and 2, whose generation is comparable with that of IS-95 systems, this block splits up the input stream in I and Q components.
The base-station-specific parameter PN offset determines the start phase of these PN short-code sequences. This permits signals of different base stations to be distinguished.
Depending on mode and spreading rate, different generation rules for PN short codes are used.

- **Direct spread 1X (and multcarrier)**:
  Generator polynomial for I and Q components of the PN short code
  $P_I(x) = x^{15}+x^{13}+x^9+x^8+x^7+x^5+1$
  $P_Q(x) = X^{15}+x^{12}+x^{11}+x^{10}+x^6+x^5+x^4+x^3+1$
  The period of a PN short-code sequence is 26.666 ms.

- **Direct spread 3X**:
  In this mode a common generator polynomial is used for the I and Q component of the PN short code. The Q component is however delayed by 2^{19} chips compared to the I component.
  $\mathbf{P_{I/Q}(x)= x^{20}+x^9+x^5+x^3+1}$
  The PN sequence is interrupted after 3 x 2^{15} chips and restarted from the beginning. Thus the period of this PN short-code sequence is also 26.666 ms.

Baseband filtering
This block performs baseband filtering (pulse shaping and band limiting) of the I/Q signal. Different filters are used in the 1X and 3X modes (direct spread). The impulse responses of these filters are listed in the standard in tabulated form. Both filters are implemented in WinIQSIM.

I/Q modulator
In the last step in the I/Q modulator, the filtered I/Q signal is modulated to the desired RF. In WinIQSIM this step is only performed for generating an IF signal. The I/Q modulator defined by the IS2000 standard differs from that defined by WinIQSIM and SMIQ. The definition used in SMIQ and WinIQSIM is used by almost all digital communication standards (except IS95 and IS2000).

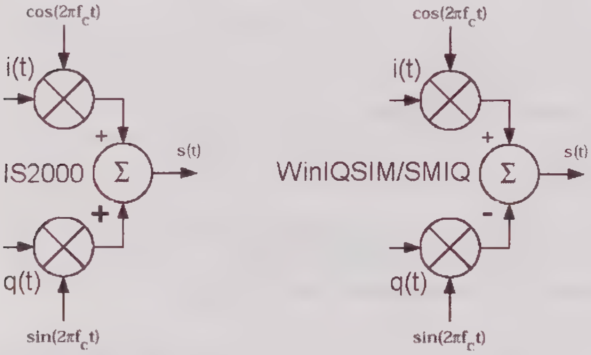


Fig. 12-4 Definition of I/Q modulator in IS2000 and WinIQSIM/SMIQ

As defined by IS2000, the RF signal s(t) is obtained from the baseband I/Q signal as follows:

$$s(t) = i(t)\cos(2\pi f_c t) + q(t)\sin(2\pi f_c t)$$

The following definition is used in WinIQSIM and SMIQ:

$$s(t) = i(t)\cos(2\pi f_c t) - q(t)\sin(2\pi f_c t)$$

To enable an I/Q demodulator defined to IS2000 to cope with an RF signal generated by SMIQ or the IF signal from WinIQSIM, the following has to be observed:

- **Generation of RF signals with SMIQ**
  The I/Q SWAP parameter in the VECTOR MOD menu must be on to be compatible with the IS2000 I/Q modulator definition. This setting may be made in SMIQ automatically by WinIQSIM. See also sections 5.25.1, Transmission Panel, and 5.25.12, SMIQ Interface and Transmission Options Panel.
- **Generation of IF signals with WinIQSIM and AMIQ**
  To be compatible with the IS2000 I/Q modulator definition, the **Inverted Q for IF** parameter in the IF Generation menu of WinIQSM must be active. See section 5.21, IF Signal Generation.

Basic constellation of I/Q signals
Depending on radio configuration and channel type, the signal components in the different channels create different subconstellations.

a) BPSK channels

With some channel types (particularly in RC1 and 2 but always in the pilot channel, for instance) the data stream is split up in I and Q components in the PN short-code scrambling block. The input data stream of this block is a real +/-1 sequence similar to BPSK. The complex output data sequence is then as follows:

$\mathbf{S_{out}(n) = d_{in}(n)\ (PN_I(n) + j\ PN_Q(n)),\ mit\ d_{in}(n),\ PN_I(n),\ PN_Q(n)} \in \{\mathbf{-1, +1}\}$.

This yields four different output combinations for S_{out}:

(-1 –j), (-1 +j), (+1 –j), (+1 +j), ie. all points are on one of the two angle bisectors at the I/Q level.

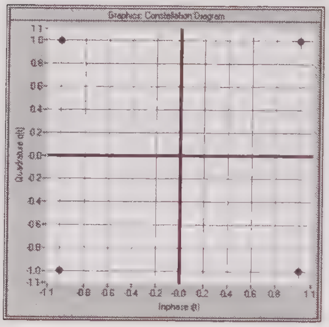


Fig. 12-5 Constellation diagram of a BPSK channel with 0 dB power

b) QPSK channels

With other channel types, the input data stream of the PN short-code scrambling block is a complex ±1 ±j sequence similar to QPSK. The complex output data sequence is then as follows:

$\mathbf{S_{out}(n) = (d_I(n) + jd_Q(n))\ (PN_I(n) + j\ PN_Q(n)),\ mit\ d_I(n),\ d_Q(n),\ PN_I(n),\ PN_Q(n)} \in \{\mathbf{-1, +1}\}$.

Table 12-2 Output combinations with QPSK channels

PN(n) \ d(n)	**-1-j**	**-1+j**	**+1-j**	**+1+j**
-1-j	+2j	+2	-2	-2j
-1+j	+2	-2j	+2j	-2
+1-j	-2	+2j	-2j	+2
+1+j	-2j	-2	+2	+2j

This again yields four different output combinations for S_{out}:

-2j, 2j, -2, 2, ie all points are on one of the two axes at the I/Q level.

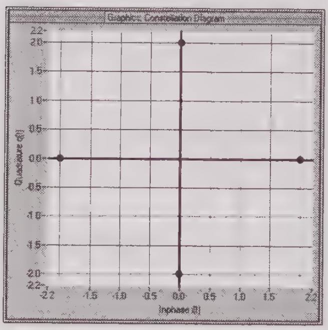


Fig. 12-6 Constellation diagram of a QPSK channel with 0 dB power

12.1.1.1.2 Multicarrier Mode (3X)

DEMUX
With the 3X multicarrier mode, the desired bandwidth is generated by combining three 1X carriers on RF frequencies spaced by 1.25 MHz. The output data stream of the power control puncturing block must be split up in three data streams, one for each carrier. All three data stream components are then routed in parallel through the function blocks described below.

Variable-length Walsh spreading
In this block the data stream components are spread to the 1X chip rate of 1.2288 Mcps. Walsh codes with a variable spread factor are used for spreading. The spreading factor and the Walsh code depend on the spreading rate, channel type, frame length and the data rate. To extend the base-station capacity, so-called 'quasi-orthogonal Walsh sets' can be used in addition to the Walsh codes. The input data stream of the spreading unit is already complex (I + jQ). If a standard Walsh code is used, spreading is effected by multiplying the input symbol (modulo 2 multiplication) with the real Walsh code. The quasi-orthogonal Walsh code results in complex spreading through an additional rotation of the output phase (the spreading code then consists of a real and an imaginary part).

PN short-code scrambling
The (complex) input data stream of the PN short-code scrambler is multiplied by a complex PN sequence (I_{PN} + j Q_{PN}). This is also called 'quadrature spreading'. The base-station-specific parameter PN offset determines the start phase of these PN short-code sequences. This permits signals of different base stations to be distinguished.
The PN short codes in the multicarrier mode are generated according to the following rule:
Generator polynomial for I and Q components of the PN short code

$$P_I(x) = x^{15}+x^{13}+x^9+x^8+x^7+x^5+1$$

$$P_Q(x) = X^{15}+x^{12}+x^{11}+x^{10}+x^6+x^5+x^4+x^3+1$$

The period of a PN short-code sequence is 26.666 ms.

Baseband filtering
This block performs baseband filtering (pulse shaping and band limiting) of the I/Q signal. In the standard the impulse response of the filter to be used is listed in tabulated form. The baseband signals of the individual carriers are filtered with the same filters as the baseband signal in the 1X direct spread mode.

I/Q modulator
In the last step, the filtered I/Q signal is modulated in the I/Q modulators to the desired RF. This step is already performed by WinIQSIM in the equivalent baseband (yields a complex baseband signal not a real RF signal).
If the multicarrier CDMA2000 signal should now be modulated to the RF via AMIQ and SMIQ or converted to the IF by WinIQSIM, the information given in section 12.1.1.1.1 should be observed.

Basic constellation of I/Q signals
When the baseband signals of the three multicarrier modes are examined separately, the same constellations are found as described further up for the direct spread mode.
The sum signal of the baseband signals already modulated (in the baseband) onto the carriers yields the following constellation:

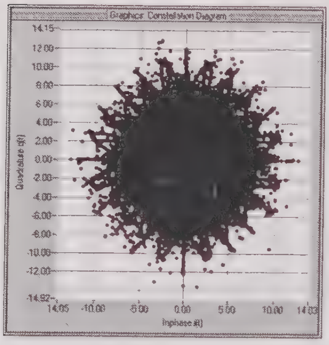


Fig. 12-7 Constellation of a BPSK channel with 0 dB power

12.1.1.2 Reverse Link

The following block diagram illustrates the generation of a code channel for the reverse link of CDMA2000.

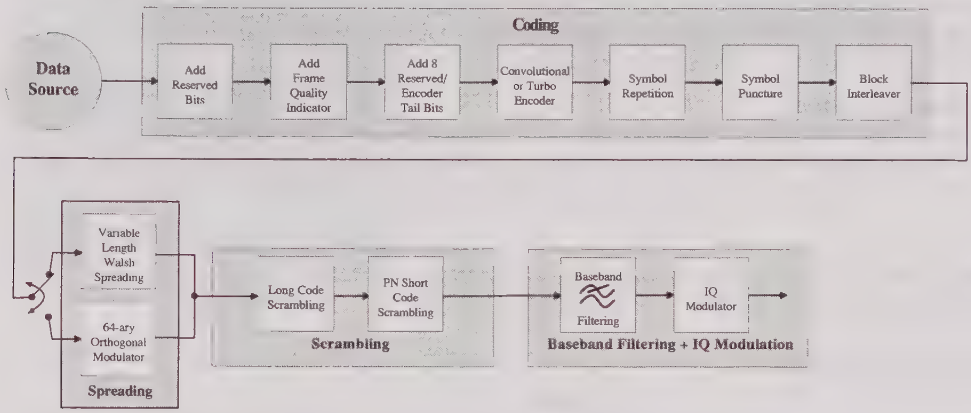

Coding
Data Source
Add Reserved Bits
Add Frame Quality Indicator
Add 8 Reserved/ Encoder Tail Bits
Convolutional or Turbo Encoder
Symbol Repetition
Symbol Puncture
Block Interleaver
Variable Length Walsh Spreading
64-ary Orthogonal Modulator
Spreading
Long Code Scrambling
PN Short Code Scrambling
Scrambling
Baseband Filtering
IQ Modulator
Baseband Filtering + IQ Modulation

Fig. 12-8 Components of CDMA2000 transmission system in the reverse link

The spreading rates 1X and 3X are defined in the reverse link of CDMA2000 same as in the forward link. Only the direct spread mode can be used, however, a multicarrier 3X mode is not defined.

The functional blocks are:

Data source
The data source used in WinIQSIM is implemented at the physical layer prior to channel coding. Channel coding of the physical layer as defined by CDMA2000 is implemented in WinIQSIM (see below). Logic channels are not assigned to the physical channel layer. If the data source is to be implemented at a higher layer, this can be done with the aid of a file interface (see section 5.6).

Channel coding
In contrast to W-CDMA, channel coding with CDMA2000 is part of the physical layer. The channel coding procedure may slightly vary depending on channel type, frame length and data rate. The basic coding procedure is illustrated by the coding block in the diagram above. Blocks like 'Add reserved bits' or 'Symbol puncture' are not used in all coding scenarios. For a more exact definition refer to the standard [2].

- **Add reserved bits**: areas reserved for future applications are filled with 0 bits.
- **Add frame quality indicator**: calculation and insertion of a CRC (cyclic redundancy code) checksum for error identification.
- **Add 8 reserved/encoder tail bits**: reserved areas for future applications or fixed data sequences are added to a data block to set the subsequent coder to a defined final state.
- **Convolutional or turbo encoder**: error correction code, depending on data rate and other parameters either by convolutional coding or turbo codes.
- **Symbol repetition**: symbol repetition is used together with bock symbol puncture for adapting the convolutional or turbo coder output data rate to the required input data rate of the interleaver.
- **Symbol puncture**: symbol puncturing (elimination) is used together with bock symbol repetition for adapting the convolutional or turbo coder output data rate to the required input data rate of the interleaver.
- **Block interleaver**: blockwise permutation of input data sequence of interleaver to avoid block errors.

Spreading

Increasing the data rate or spreading in the reverse link is performed in different ways depending on the radio configuration and the channel type.

- **Variable-length Walsh spreading**
  Walsh codes with a variable spread factor are used for spreading. The spreading factor and the Walsh code depend on the spreading rate, channel type, frame length and the data rate. Spreading is obtained by multiplication of the input symbol (modulo 2 multiplication) by the real Walsh code.
- **64ary orthogonal modulator**
  Groups of 6 input bits are used for addressing a line of the Walsh code table with the spread code length of 64. This 'modulator' increases the data rate by a factor of 64/6. This type of rate increase comes from IS-95 and is mainly used in the radio configurations 1 and 2.

Scrambling

In the scrambling block the spread data stream is scrambled by means of the long code and the PN short code. Different methods are used for the radio configurations 1, 2 and RC3 to RC6.

a) Scrambling for RC1 and RC2

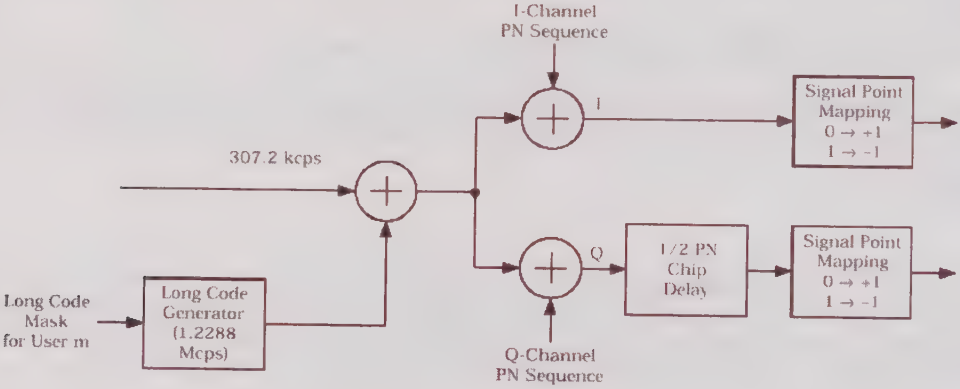


Fig. 12-9 Scrambling in the reverse link of RC1 and RC2

The output data stream of the spreading block is scrambled with the **long code**. The rate is increased in addition by a factor of four. The long-code generator is also referred to as scrambling code generator since it scrambles the chip sequence in a user-specific way (long-code mask). This generator exactly corresponds to that described in section 12.1.1.1 for the forward link.

The real input data stream of the **PN short-code** scrambler is multiplied by a complex PN sequence (I_{PN} + j Q_{PN}). This procedure is also called 'quadrature spreading'. With channels of the radio configurations 1 and 2, whose generation is comparable with that of IS-95 systems, this block splits up the input stream in I and Q components.
In contrast to the forward link, no variable PN offset parameter is available for the PN short code in the reverse link. The PN offset is always 0.

Different generation rules are used for the PN short codes depending on the mode and spreading rate. The generator polynomials of the PN short codes correspond to those in the forward link (see 12.1.1.1). The I and Q data streams consisting of {0, 1} sequences are then mapped to {+1, -1} in the **signal point mapping** block.

Because of the delay of the Q component, offset QPSK constellation known from the reverse link of IS-95 is obtained from the QPSK constellation. Due to the Q delay, the transfer of the I and Q signal components from one chip to the next is never synchronous. For this reason there are no zero crossings in the transfer from one chip to the next. This behaviour can be seen in the vector diagram below.

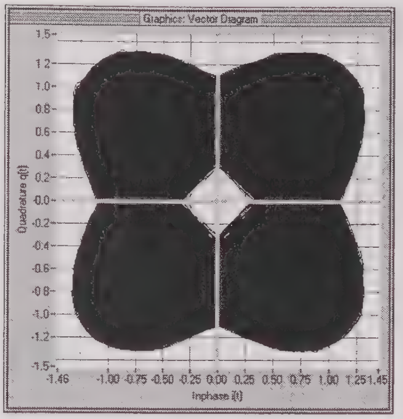


Fig. 12-10 Vector diagram of reverse link channel of RC1

b) Scrambling für RC3 bis RC6

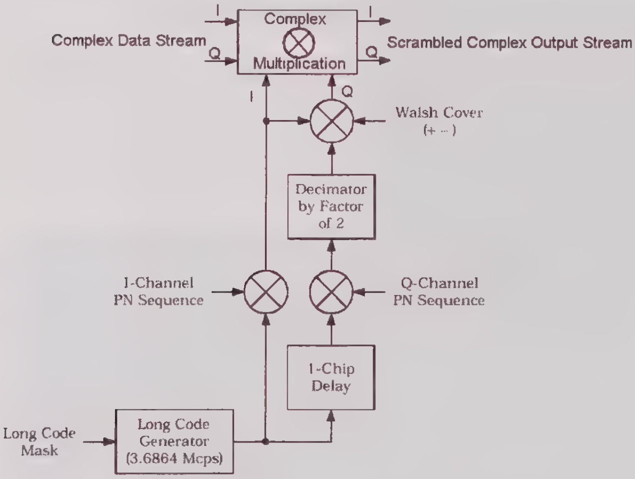


Fig. 12-11 Scrambling in the reverse link with spreading rate 3X (RC5 or RC6)

Here too, the long-code generator defined in section 12.1.1.1 for the forward link is used. A distinction is again made between the 1X and 3X spreading rates. A complex long-code sequence is required. For this purpose, the output sequence of the generator is used as the I component and the sequence delayed by one chip as the Q component.

The I component of the long code is then multiplied by the I component of the PN short code, the Q component with the corresponding Q component of the PN short code. The definition of the PN short code is given in section 12.1.1.1

The subsequent operations **decimation by factor of 2** and linking the Q component to the Walsh sequence (+-) and the I component serve for reducing the zero crossings of the I/Q signal at the end of the whole scrambling process. Thus a behaviour similar to that in the reverse link of 3GPP W-CDMA is obtained. It is also known as HPSK (hybrid phase shift keying).

The resulting I/Q output stream is obtained by complex multiplication (modulo 2) of the I/Q input sequence of the scrambler by the complex scramble sequence obtained from the long code and the PN short code. The constellation obtained is a combination of QPSK and offset QPSK. The effect of this special scrambling on the frequency of the zero crossings in WinIQSIM is shown in the constellation diagram when the **Density Coloring All** option is active (see also section 5.20.3.8, Constellation

Diagram) In the left diagram (reverse link) there are far less zero crossings than in the diagram at the right (forward link).

In this mode, the traffic data streams of a channel are mapped either to the I or to the Q path of the complex data stream shown in the diagram above. With these so-called BPSK channels, the channel component at the scrambler input consists of a real or an imaginary component. As can be seen in the table below, the constellation after complex scrambling is again at the angle bisector.

Table 12-3 Output combinations with BPSK channels

d(n) \ S-Code(n)	-1-j	-1+j	+1-j	+1+j
-1	+1+j	+1-j	-1+j	-1-j
+1	-1-j	-1+j	+1-j	+1+j
-j	-1+j	+1+j	-1-j	+1-j
+j	+1-j	-1-j	+1+j	-1+j

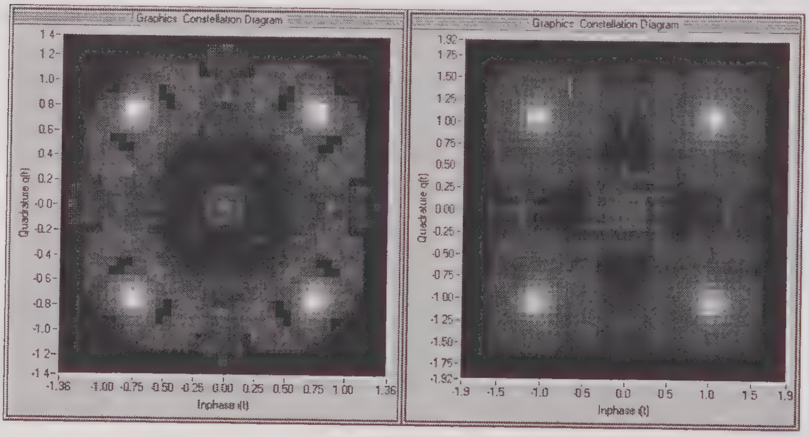


Fig. 12-12 Constellation Diagramm mit Density Coloring 3X RC5 Reverse Link und Forward Link

The subsequent blocks in the transmission system of the reverse link are identical for both scrambling methods.

Baseband filtering

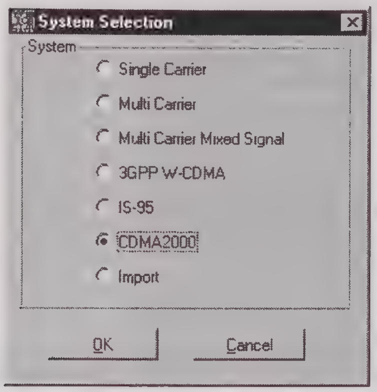
This block performs baseband filtering (pulse shaping and band limiting) of the I/Q signal. Different filters are used in the 1X and 3X modes (direct spread). The impulse responses of these filters are listed in the standard in tabulated form. Both filters are implemented in WinIQSIM.

I/Q modulator

In the last step in the I/Q modulator, the filtered I/Q signal is modulated to the desired RF. In WinIQSIM this step is only performed for generating an IF signal. The I/Q modulator defined by the IS2000 standard differs from that defined by WinIQSIM and SMIQ. For more information refer to section 12.1.1.1

12.2 Generation of CDMA2000 Signals with WinIQSIM

To generate a CDMA2000 signal to IS2000 standard, the CDMA2000 system has to be selected first.



System Selection

System

○ Single Carrier
○ Multi Carrier
○ Multi Carrier Mixed Signal
○ 3GPP W-CDMA
○ IS-95
● CDMA2000
○ Import

Fig. 12-13 Selection of CDMA2000 system

System selection is accessible from the File/New... or System menu.
The differences between the two methods are described in sections 5.22.1 and 5.23.

The CDMA2000 block diagram is based on that of the single carrier system. The data source block has been enhanced and the modulation block replaced by the CDMA2000 configuration block.

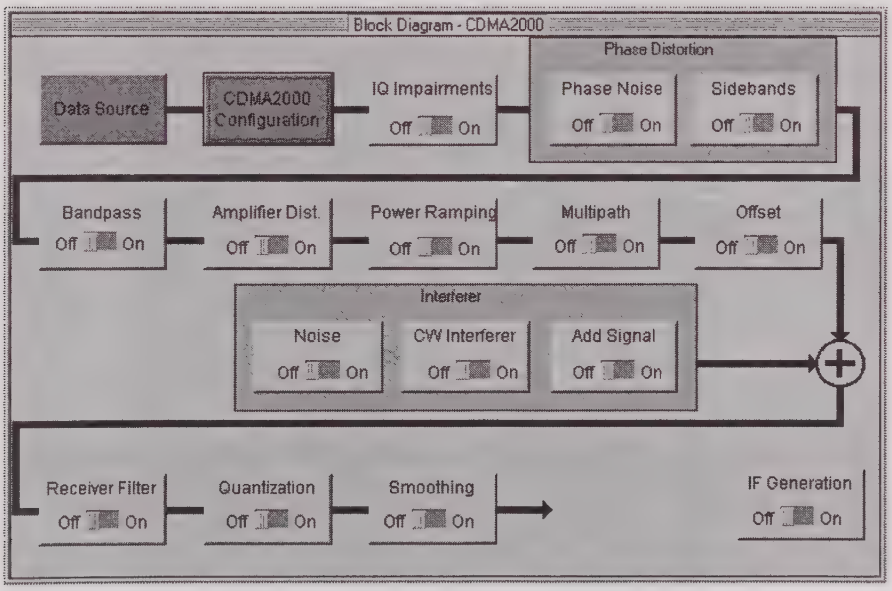


Fig. 12-14 Block diagram of CDMA2000 system

The data source block corresponds to that of the multicarrier system. For description of the data source see section 7.2.

12.2.1 Status Line

The main parameters of the CDMA2000 transmission system are displayed in the status line below the toolbar of the main panel. The set parameters can thus be seen at a glance.

The status line contains symbols for the different parameters; below the symbols the current parameter values are indicated. The figure below shows the status line of the CDMA2000 system with the parameters assigned to the symbols.

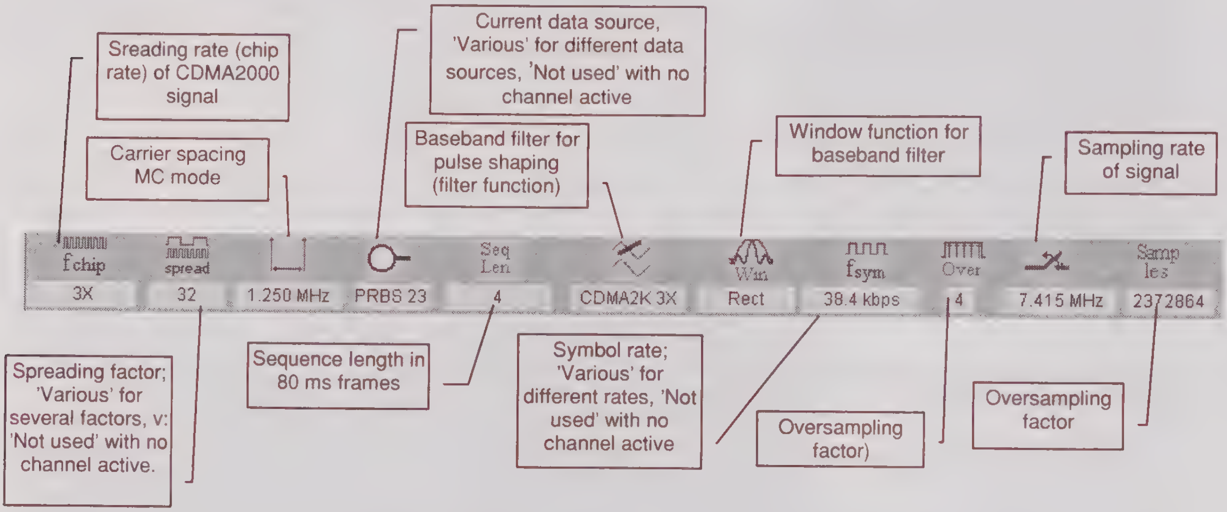
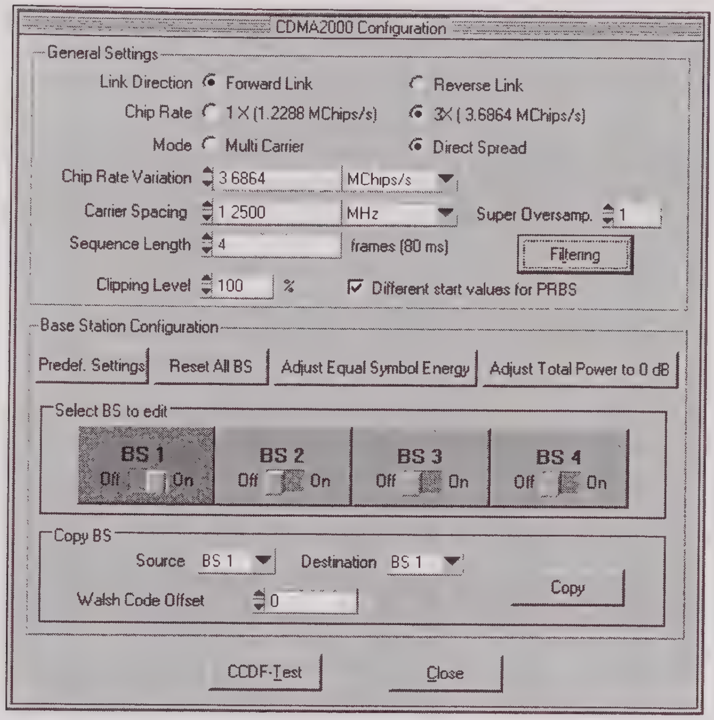

Sreading rate (chip rate) of CDMA2000 signal
Current data source, 'Various' for different data sources, 'Not used' with no channel active
Carrier spacing MC mode
Baseband filter for pulse shaping (filter function)
Window function for baseband filter
Sampling rate of signal
fchip
spread
Seq Len
Win
fsym
Over
Samp les
3X
32
1.250 MHz
PRBS 23
4
CDMA2K 3X
Rect
38.4 kbps
4
7.415 MHz
2372864
Spreading factor; 'Various' for several factors, v: 'Not used' with no channel active.
Sequence length in 80 ms frames
Symbol rate; 'Various' for different rates, 'Not used' with no channel active
Oversampling factor)
Oversampling factor

Fig. 12-15 Status line of CDMA2000 system

12.2.2 CDMA2000 Configuration Panel

All parameters that are required for the definition of a CDMA2000 signal (with the exception of data sources and impairments) can be accessed via the CDMA2000 Configuration panel. The following diagrams show the panel in the forward and reverse link directions.


CDMA2000 Configuration

General Settings

Link Direction ● Forward Link ○ Reverse Link

Chip Rate ○ 1 X (1.2288 MChips/s) ● 3X (3.6864 MChips/s)

Mode ○ Multi Carrier ● Direct Spread

Chip Rate Variation 3.6864 MChips/s

Carrier Spacing 1.2500 MHz Super Oversamp. 1

Sequence Length 4 frames (80 ms)

Clipping Level 100 %

☑ Different start values for PRBS

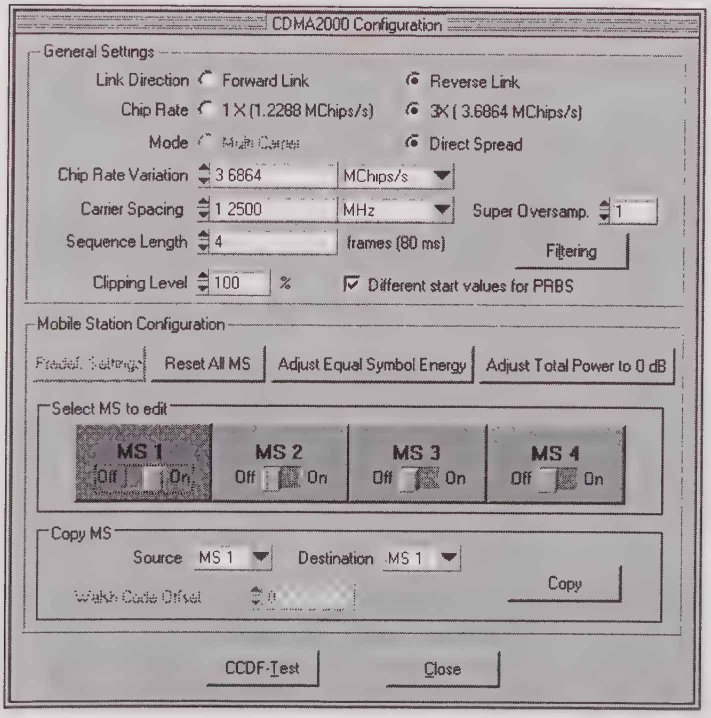
Base Station Configuration

Copy BS

Source BS 1 Destination BS 1

Walsh Code Offset 0

Fig. 12-16 The CDMA2000 Configuration panel in the forward link


CDMA2000 Configuration

General Settings

Link Direction ○ Forward Link ● Reverse Link

Chip Rate ○ 1 X (1.2288 MChips/s) ● 3X (3.6864 MChips/s)

Mode ○ Multi Carrier ● Direct Spread

Chip Rate Variation 3.6864 MChips/s

Carrier Spacing 1.2500 MHz Super Oversamp. 1

Sequence Length 4 frames (80 ms)

Clipping Level 100 %

☑ Different start values for PRBS

Mobile Station Configuration

Copy MS

Source MS 1 Destination MS 1

Walsh Code Offset 0

Fig. 12-17 The CDMA2000 Configuration panel in the reverse link

12.2.2.1 General Settings

The following parameters are defined in the General Settings window:

- **Link Direction**
  Forward link, ie from the base station to the mobile station, or reverse link, ie from the mobile station to the base station. The lower section of the window depends on the link direction. In the downlink mode, the lower section is used to configure the base stations and in the uplink mode to configure the mobile stations.
- **Chip Rate**
  The desired chip rate or spreading rate of the signal can be selected. Rates 1X (1.288 MChips/s) and 3X (3.864 MChips/s) can be selected.
- **Mode**
  A choice can be made here whether the CDMA2000 is generated in the direct-spread or multicarrier mode. In the forward link, the multicarrier mode is only available with spreading rate 3X. In the reverse link only the direct-spread mode can be used.
  Direct Spread: The transmission bandwidth of the CDMA2000 signal is obtained by direct spreading of the traffic data stream to the spreading rate. The resulting signal occupies an RF carrier of 1X or 3X bandwidth.
  Multi Carrier (3X): The traffic data stream is first divided into three low-rate streams by means of a demultiplexer. Each of the low-rate streams is spread to the rate 1X and then modulated onto three RF carriers (spaced 1.25 MHz)
- **Chip Rate Variation**
  This parameter defines the actual chip rate of the output signal. While the chip rate parameter defines the type of spreading, the chip rate variation determines the rate of the spread symbols as is used for signal output by AMIQ. This value is set as standard to the value of the chip rate, ie also when the chip rate is changed.

  Note: *The chip rate of the baseband signal of a carrier in the multicarrier 3X mode is one third of the chip rate variation parameter indicated and settable in the panel. With a chip rate variation of 3.6864 MChips/s, the baseband chip rate of a carrier is therefore 1.2288 MChips/s.*
- **Carrier Spacing**
  This parameter defines the carrier spacing in the 3X multicarrier mode. The value of 1.25 MHz specified in the standard is normally set. Another value may however be set, eg for testing tolerances at the receiver end.
- **Super Oversampling**
  With this parameter, which is only relevant in the multicarrier mode, the total sampling rate of the signal can be increased, for instance for shifting the recurrent spectra of the output signal at higher frequencies. The total sampling rate in the multicarrier 3X mode is then as follows:

  $$f_{sample} = \mathbf{superoversampling} \cdot ((\mathbf{number\_of\_carriers} - 1) \cdot \mathbf{carrier\_spacing} + \mathbf{oversampling} \cdot \mathbf{chip\_rate})$$

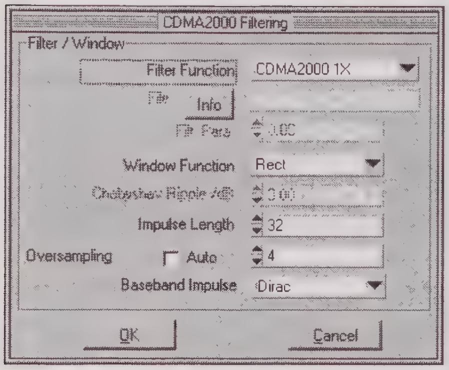
  $$\overset{\mathbf{n\_carrier=3}}{\Rightarrow} \quad f_{sample} = \mathbf{superoversampling} \cdot (2 \cdot \mathbf{carrier\_spacing} + \mathbf{oversampling} \cdot \mathbf{chip\_rate})$$
- **Sequence Length**
  The length of the signal to be generated is set in frames (80 ms).
  The 80 ms frame spacing was chosen because both the SYNC channel with a period of 26.67 ms and all other channels with frame lengths of 5 ms, 10 ms, 20 ms or 80 ms fully fit into this scheme. The number of chips is determined by the sequence length (1 frame = 80 ms) and the actual chip rate. A frame thus corresponds to 98,304 chips at a spreading rate 1X (1.2288) MChips/s and to 294,912 chips when 3X direct spread is chosen.
- **Clipping**
  In this field a clipping value can be set as a percentage of the highest peak of the I/Q signal. The value range is 1 to 100%. A value of 100% means that the signal is not clipped. Clipping reduces the crest factor. For more detailed information on the use of this parameter refer to section 8.2.2.8.

- **Different start values for PRBS**
  If this parameter is active, the PRBS generators of the individual channels are initialized with different start values. As a result, all channels are calculated with independent source data.

  Note: *This switch is only effective with 'Data Source PRBS' selected. If 'Data Source 0' is used for PRBS16, for instance, this switch is ignored, ie all channels using Data Source 0 are calculated with identical PRBS bit sequences.*

12.2.2.2 Filtering

The generated raw chips are subjected to baseband filtering which is implemented equivalent to the single carrier system.



Filter Function: CDMA2000 1X
Window Function: Rect
Impulse Length: 32
Oversampling ☐ Auto: 4
Baseband Impulse: Dirac

Fig. 12-18 CDMA2000 filtering

The description of the individual parameters can therefore be found in section 5.8, Modulation Settings Panel.

Note: *The parameters in the above filter panel are recommended for filtering CDMA2000 signals in the 1X direct-spread mode and the 3X multicarrier mode. For the 3X direct-spread mode, the* ***CDMA2000 3X DS*** *filter specified in the standard should be chosen in the Filter Function field.*

12.2.2.3 Base Station/Mobile Station Configuration

Depending on the spreading rate and the radio configuration, signals with up to 364 code channels in the forward link and up to 52 code channels in the reverse link can be simulated in the CDMA2000 system. The 364 or 52 channels are distributed to 4 base stations or mobile stations with up to 91 or 13 channels each. This allows clear processing of a large number of channels and simulation of scenarios consisting of several base stations or mobile stations. The system can also be configured so that several BS/MS are combined to one. A BS/MS of more than 91 or 13 code channels can thus be simulated (see also Copy BS/MS further down in this section).

For a detailed description of all possible scenarios and for modelling them in WinIQSIM see section 12.3

12.2.2.3.1 Common Setting of all Base Stations/Mobile Stations

The base station/mobile station configuration window comprises several buttons the function of which will now be described. The functions are identical in the two link directions but not all parameters and buttons can be used for the two link directions.

Predef. Settings: If this button is selected, which is only active for the forward link, a window is opened where parameterizable predefined settings can be defined. Complex scenarios can thus be easily generated. For further information see section **0**.

Reset All BS: All base stations are reset to predefined parameters. For reset values see table below.

Table 12-4 Reset values for base stations

Common parameters of BS	**Reset value (BS 1, BS 2, BS 3, BS 4)**
State	Off for all BS
Radio configuration	Spreading rate 1X: RC1 for all BS Spreading rate 3X: RC6 for all BS
PN offset	0, 1, 2, 3
Quasi-orthogonal Walsh set	Off for all BS
Use OTD	Off for all BS
Coding	Off for all BS
(Mis-)Use of TPC for output power control	Off for all BS
Power step	0 dB for all BS

Parameters of code channels	**Reset value (BS 1, BS 2, BS 3, BS 4)**
Frame length	Dep. on channel type, 20 ms if possible, otherwise lowest possible frame length.
Data rate	Dep. on channel type, 9.6 kbps if possible, otherwise lowest possible data rate
Walsh code	Dep. on channel type, channel number in the table, otherwise lowest possible Walsh code
Quasi-orth. spreading	Off for all channels
Long-code mask	0 for all channels
Power	0 dB for all channels
Data source	PRBS for all channels
TPC pattern	0 for all channels
State	Off for all channels

Reset All MS: All mobile stations are reset to predefined settings. For reset values see table below.

Table 12-5 Reset values for mobile stations

Common parameters of MS	**Reset value (MS 1, MS 2, MS 3, MS 4)**
State	Off for all MS
Radio configuration	Spreading rate 1X: RC1 for all MS Spreading rate 3X: RC6 for all MS
Coding	Off for all BS
TPC pattern	"0“
(Mis-)Use of TPC for output power control	Off for all BS
Power step	0 dB for all BS

Parameters of code channels	**Reset value (MS 1, MS 2, MS 3, MS 4)**
Frame length	Dep. on channel type, 20 ms if possible, otherwise lowest possible frame length.
Data rate	Dep. on channel type, 9.6 kbps if possible, otherwise lowest possible data rate
Long-code mask	0 for all channels
Power	0 dB for all channels
Data source	PRBS for all channels
State	Off for all channels

Adjust Equal Symbol Energy: The power of the individual code channels is set so that the energy of the useful symbols is equal prior to spreading. Since spreading accelerates the process by the spreading factor, the transmit power of a code channel can be reduced by this factor to obtain the same characteristics as before the spreading. The channel power of the individual code channels is set so that the product of the spreading factor and transmit power is constant. Channels with a large spreading factor are weighted with a smaller transmit power than those with a lower spreading factor.

Adjust Total Power to 0 dB: The power of the individual code channels is set so that the sum power of all active channels is 0 dB. The set power differences of the channels remain the same but the total power is normalized to 0 dB. This mode can be used to send the individual code channels from Signal Generator SMIQ (with a set effective transmit power of 0 dB) at the power indicated by WinIQSIM.

Select BS/MS to edit: In this section, the base station/mobile stations are indicated in the form of blocks. They can be switched on or off. Active BS/MS blocks are green, passive BS/MS blocks are grey. The currently active stations can thus be seen at a glance. To edit the parameters of a base station/mobile station, click on the corresponding BS/MS block. A setting window is opened to configure the BS/MS (also see sections 12.2.2.5 and 12.2.2.6).

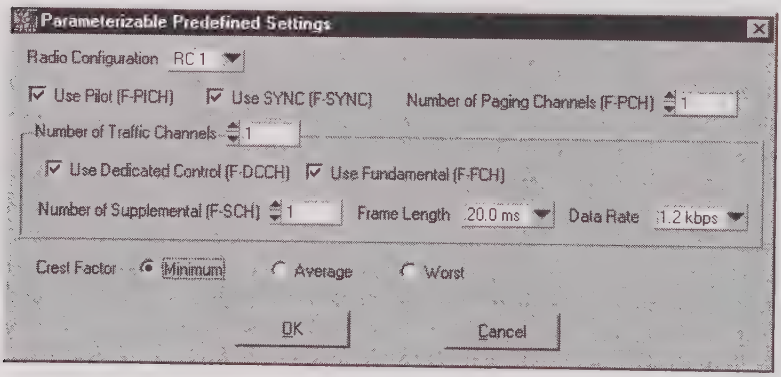
Copy BS/MS: In this window the configuration of one BS/MS can be copied for another BS/MS. Select the BS/MS to be copied in the Source field and the BS/MS to be overwritten in the Destination field. Start copying by pressing the Copy button. It is thus possible to generate a scenario of several BS/MS after configuring one BS/MS. To simulate different BS/MS afterwards, only the BS/MS-specific parameter such as PN offset have to be modified.
With the aid of the Walsh code offset parameter (available in the forward link only), WinIQSIM can be easily configured for a BS to be simulated with more than 91 channels (for RC1). When copying, the Walsh code number of each channel of the new BS/MS is increased by the value set in the Walsh Code Offset field as against the reference channel in the source BS/MS.

CDF Test: This button opens a window in which the so-called 'complementary cumulative distribution function' is displayed. For further information see section 12.3

Close: Pressing this button closes the CDMA2000 configuration panel.

12.2.2.4 Parameterizable Predefined Settings

This panel is used to define parameterizable predefined settings. Complex scenarios can thus be easily defined. The panel is only available in the forward link.


Parameterizable Predefined Settings

Radio Configuration RC 1

☑ Use Pilot (F-PICH) ☑ Use SYNC (F-SYNC) Number of Paging Channels (F-PCH) 1

Number of Traffic Channels 1

☑ Use Dedicated Control (F-DCCH) ☑ Use Fundamental (F-FCH)

Number of Supplemental (F-SCH) 1 Frame Length 20.0 ms Data Rate 1.2 kbps

Crest Factor ● Minimum ○ Average ○ Worst

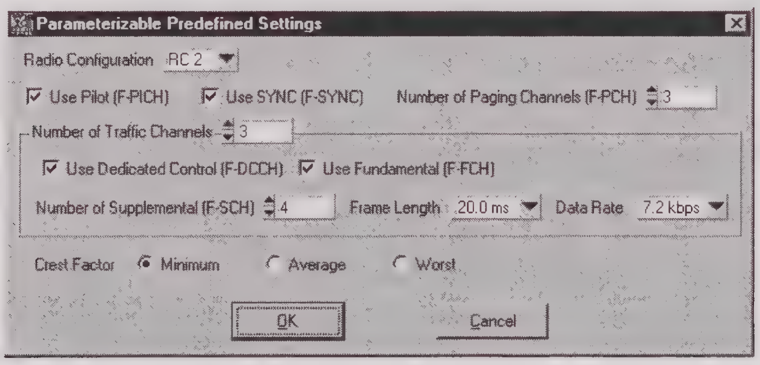
Fig. 12-19 Parameterizable Predefined Settings panel

The **Radio Configuration,** for which a test signal is to be generated, is determined first. Depending on the spreading rate, a configuration can be selected from RC1 to RC5 or RC6 to RC9 (3X).
It can also be specified whether the signal should contain a pilot channel (**Use Pilot**), a sync channel (**Use SYNC**) and how many paging channels (**Number of Paging Channels**) should be used.

In WinIQSIM, a base station may contain up to eight so-called traffic channels. Every traffic channel consists of a dedicated control channel, a fundamental channel and, depending on the radio configuration) up to seven supplementary channels. For details refer to section 0.
First select the number of traffic channels (1 to 8). The parameters defined separately within the window configure all traffic channels used in the scenario. This means that all traffic channels selected in the Number of Traffic Channels field are of identical structure.
The **Use Dedicated Control** and **Use Fundamental** fields offer the choice whether the respective channels should be contained in the traffic channels or not.
Finally the number of supplemental channels per traffic channel (**Number of Supplemental**) is defined, likewise their frame length (**Frame Length**) and data rate (**Data Rate**). The value range of the individual parameters depends on the radio configuration and for the data rate also on the frame length.

In the **Crest Factor** area below it can be specified whether a **Minimum, Average** or **Worst** crest factor should be used for the signal scenario. WinIQSIM automatically selects the channel parameters for the required scenario by varying the Walsh code number of the code channels.
When clicking the OK button, the parameters and the channel tables of the individual base stations are automatically configured as given by the parameters indicated. Base station 1 is automatically activated and all others are switched off.

Example: ➢ Set the parameters in the Parameterized Predefined Settings panel as shown in Fig. 12-20 below.



Radio Configuration RC 2

☑ Use Pilot (F-PICH) ☑ Use SYNC (F-SYNC) Number of Paging Channels (F-PCH) 3

Number of Traffic Channels 3

☑ Use Dedicated Control (F-DCCH) ☑ Use Fundamental (F-FCH)

Number of Supplemental (F-SCH) 4 Frame Length 20.0 ms Data Rate 7.2 kbps

Crest Factor ● Minimum ○ Average ○ Worst

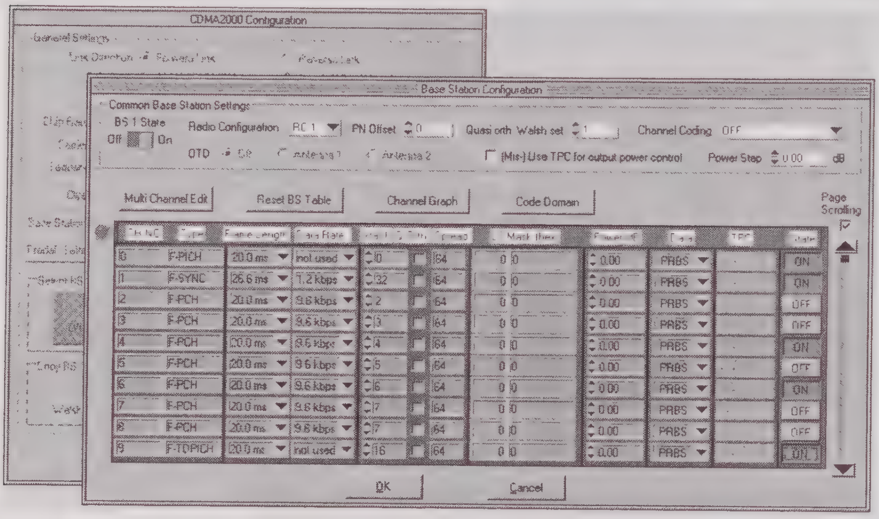
Fig. 12-20 Parameterizable Predefined Settings panel

After confirming the settings with OK, the following signal scenario is set.

- Base station 1 is activated, all other base stations are switched off.
- Radio configuration 2 is set for BS1.
- The pilot, the SYNC and three paging channels are activated in BS1.
- Three traffic channels of BS1 are configured as follows:
- The dedicated control channel and the fundamental channel of all three traffic channels are switched on. If possible, the frame length and data rate selected for the supplemental channel should also be used for these channels.
- Four fundamental channels each with a frame length of 20 ms and a data rate of 7.2 kbps are activated.
- The Walsh codes of the activated channels are selected at crest factor minimum so that a low crest factor is obtained..

12.2.2.5 Base Station Configuration

A click on one of the base station blocks in the CDMA2000 Configuration panel opens the Base Station Configuration panel. The CDMA2000 Configuration panel is also displayed but it is dimmed since the two windows are interrelated in many ways. The CDMA2000 configuration parameters can still be read but not changed. When the Base Station Configuration panel is closed (with OK or Cancel), the CDMA2000 Configuration panel is enabled again.



Common Base Station Settings

BS 1 State Off On

Radio Configuration RC 1

PN Offset 0

Quasi orth. Walsh set 1

Channel Coding OFF

OTD ● Off ○ Antenna 1 ○ Antenna 2

☐ (Mis-) Use TPC for output power control

Power Step 0.00 dB

Ch.No	Type	Frame Length	Data Rate	Walsh	Q. Orth	Spread	Mask (hex)		Power dB	Data	TPC	State
0	F-PICH	20.0 ms	not used	0	☐	64	0	0	0.00	PRBS	-	ON
1	F-SYNC	26.6 ms	1.2 kbps	32	☐	64	0	0	0.00	PRBS	-	ON
2	F-PCH	20.0 ms	9.6 kbps	2	☐	64	0	0	0.00	PRBS		OFF
3	F-PCH	20.0 ms	9.6 kbps	3	☐	64	0	0	0.00	PRBS		OFF
4	F-PCH	20.0 ms	9.6 kbps	4	☐	64	0	0	0.00	PRBS	-	ON
5	F-PCH	20.0 ms	9.6 kbps	5	☐	64	0	0	0.00	PRBS	-	OFF
6	F-PCH	20.0 ms	9.6 kbps	6	☐	64	0	0	0.00	PRBS	-	ON
7	F-PCH	20.0 ms	9.6 kbps	7	☐	64	0	0	0.00	PRBS	-	OFF
8	F-PCH	20.0 ms	9.6 kbps	7	☐	64	0	0	0.00	PRBS		OFF
9	F-TDPICH	20.0 ms	not used	16	☐	64	0	0	0.00	PRBS	-	ON

Fig. 12-21 Base Station Configuration panel

12.2.2.5.1 Common Base Station Settings

The parameters set in this panel window are valid for the complete base station.

BS State: The complete base station can be switched on or off.

Radio configuration
The radio configuration parameter is comparable with selecting the rate sets of IS-95. The radio configuration influences the whole structure of the channel table. It determines among other things the channel types defined and the frame lengths and data rates that can be used. Depending on the spreading rate, the following radio configurations can be set.
Spreading rate 1X: RC1 – RC5
Spreading rate 3X: RC6 – RC9

PN offset
A PN offset can be set for each base station. This value is used as time offset for the PN generators. The value range is [0 to 511].

Quasi-orthogonal Walsh set
To extend the base-station capacity, the so-called 'quasi-orthogonal Walsh sets' can be used in addition to the Walsh codes. When the quasi-orthogonal Walsh code is used, spreading the data stream results in complex spreading also through an additional rotation of the output phase (the spreading code then consists of a real and an imaginary part).
One of the three quasi-orthogonal Walsh codes defined in the standard can be selected. In the channel table further down in the panel, a decision can be made for each channel (permissible by the standard) whether the Walsh code of the standard set or of the quasi-orthogonal set should be used.

OTD

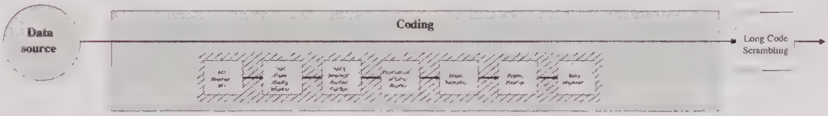
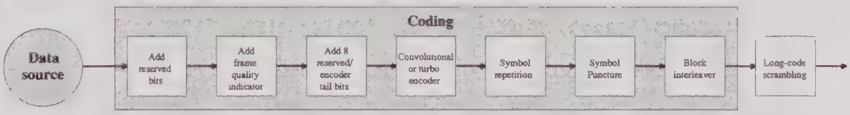
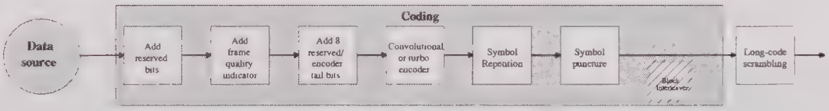
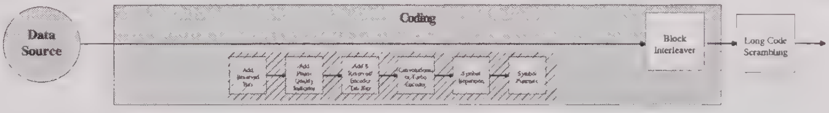
OTD stands for orthogonal transmit diversity. This parameter has a similar effect as the transmit diversity parameter used by 3GPP W-CDMA. The CDMA2000 signal can be sent simultaneously on several antennas. As a result, the receiver can decode the traffic signal from the two input signals and is less liable to fading and other interference.

If OTD should be used, the antenna of which the signal should be simulated can be specified. Generation of the signal depends on the selected antenna. For further details refer to [2].

Channel coding

With this parameter you can decide whether the code channels of the base station should be channel-coded Channel coding is performed as described in section 12.1.1.1. Depending on channel type and radio configuration, blocks like **Add Reserved Bits** may not be available. To test the individual components of the channel coding in your receiver, four coding modes are offered which are explained in the table below.

Table 12-6 Channel coding modes

Coding mode	Function / structure
Off	Channel coding is not performed. The data sources of the individual channels apply their data stream directly to the long-code scrambler. The data source supplies the traffic data with the data rate that would be available at the long-code scrambler after coding is switched on. The data rate parameter indicated in the channel table is no longer valid. 
Complete	The complete channel coding (see 12.1.1.1) is performed.  Data source Coding Add reserved bits Add frame quality indicator Add 8 reserved/ encoder tail bits Convolutional or turbo encoder Symbol repetition Symbol Puncture Block interleaver Long-code scrambling
Without interleaving	Except for the block interleaver, the whole channel coding procedure is carried out. In this mode the frame structure and the convolutional coder of your receiver can be tested.  Data source Coding Add reserved bits Add frame quality indicator Add 8 reserved/ encoder tail bits Convolutional or turbo encoder Symbol Repetition Symbol puncture Block interleaver Long-code scrambling
Interleaving only	In this mode only block interleaver is used for coding. This allows the deinterleaver in the receiver to be tested independently of the remaining (de-)coding process.  Data Source Coding Block Interleaver Long Code Scrambling

(Mis-)Use TPC for output power control / Power Step:
The TPC (transmit power control) bits are used by CDMA2000 to signal an increase or decrease of the output power to the destination station. To this end the data stream is punctured after long-code scrambling at the frequency of 800 Hz and one to six information bits are replaced by a corresponding number of power control bits (0 to 0 or 1 to 1).
If the **(Mis-)Use TPC** option is active, the specified pattern is misused to vary the output power as a function of time. Every 1.25 ms (800 Hz), a bit of this pattern is used to increase (bit = 1) or decrease (bit = 0) the channel power by the specified power step. The upper limit is 0 dB and the lower limit -60 dB.

The following envelope is obtained at a channel power of 0 dB, power step of 1.0 dB and the pattern 001110100000011:

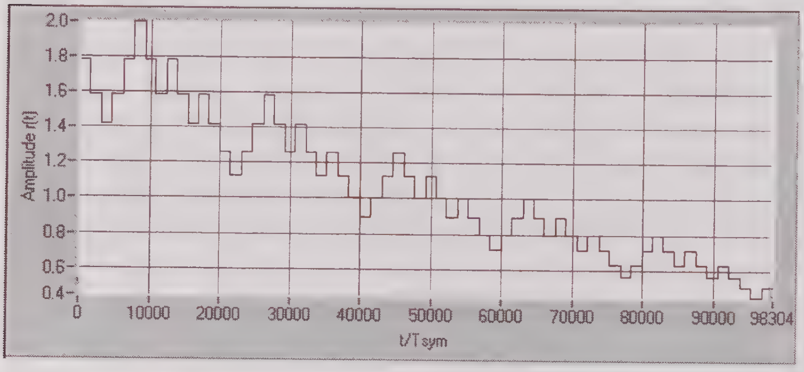


Fig. 12-22 Dynamic change of channel power

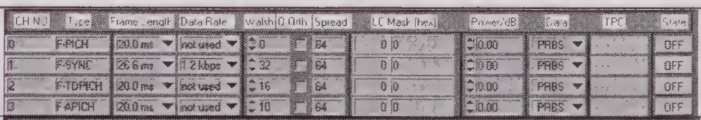
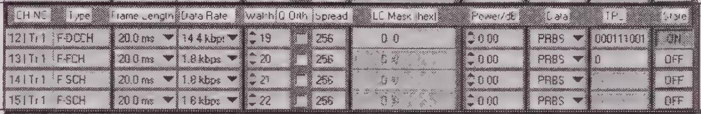
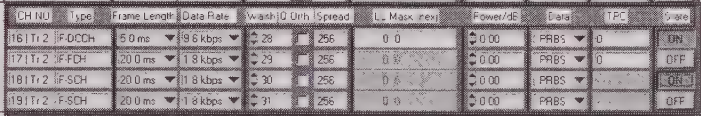
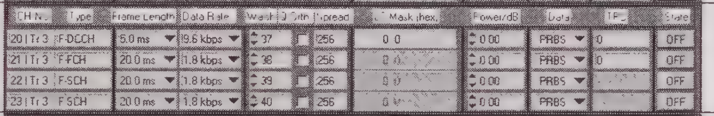
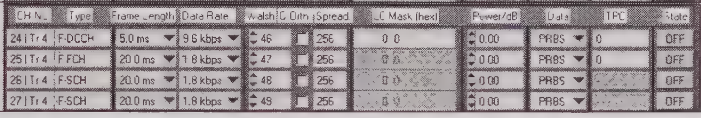
Note that the first bit is assigned to the first power control section. In this first section the start power specified in the channel table is always used, ie only in the next power control section (with the second TPC bit) will the defined power change be effective

12.2.2.5.2 Channel Table of a Base Station

Most of the base station configuration panel is taken up by the scrollable channel table. The table elements can be directly edited or changed. The parameters that can be changed in the individual table columns are described in the following.

Basic table structure:
Two different classes of channels are available in the CDMA2000 forward link. There are channels like pilot, sync, paging and control channels which contain control information but no dedicated information for the recipient. These channels are called **special channels**. Then dedicated channels are defined containing information for the recipient. These channels are called **traffic channels**. A traffic channel in CDMA2000 may consist of several subchannels. In WinIQSIM, up to eight traffic channels including subchannels can be defined for each base station in addition to the special channels.
To show the assignment of the channels to the various groups and for the sake of clarity, the lines in the channel table are assigned colours for the different groups.

Table 12-7 Assignment of channel groups in the channel table

Channel group	Display in the channel table
Special channels	
Traffic channels 1 and 5	
Traffic channels 2 and 6	
Traffic channels 3 and 7	
Traffic channels 4 and 8	

CH NO	Type	Frame Length	Data Rate	Walsh	Q Orth	Spread	LC Mask (hex)	Power/dB	Data	TPC	State
0	F-PICH	20.0 ms	not used	0	☐	64	0 0	0.00	PRBS		OFF
1	F-SYNC	26.6 ms	1.2 kbps	32	☐	64	0 0	0.00	PRBS		OFF
2	F-TDPICH	20.0 ms	not used	16	☐	64	0 0	0.00	PRBS		OFF
3	F-APICH	20.0 ms	not used	10	☐	64	0 0	0.00	PRBS		OFF

CH NO	Type	Frame Length	Data Rate	Walsh	Q Orth	Spread	LC Mask (hex)	Power/dB	Data	TPC	State
12 | Tr 1	F-DCCH	20.0 ms	14.4 kbps	19	☐	256	0 0	0.00	PRBS	000111001	ON
13 | Tr 1	F-FCH	20.0 ms	1.8 kbps	20	☐	256	0 0	0.00	PRBS	0	OFF
14 | Tr 1	F-SCH	20.0 ms	1.8 kbps	21	☐	256	0 0	0.00	PRBS		OFF
15 | Tr 1	F-SCH	20.0 ms	1.8 kbps	22	☐	256	0 0	0.00	PRBS		OFF

CH NO	Type	Frame Length	Data Rate	Walsh	Q Orth	Spread	LC Mask (hex)	Power/dB	Data	TPC	State
16 | Tr 2	F-DCCH	5.0 ms	9.6 kbps	28	☐	256	0 0	0.00	PRBS	0	ON
17 | Tr 2	F-FCH	20.0 ms	1.8 kbps	29	☐	256	0 0	0.00	PRBS	0	OFF
18 | Tr 2	F-SCH	20.0 ms	1.8 kbps	30	☐	256	0 0	0.00	PRBS		ON
19 | Tr 2	F-SCH	20.0 ms	1.8 kbps	31	☐	256	0 0	0.00	PRBS		OFF

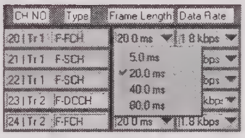
CH NO	Type	Frame Length	Data Rate	Walsh	Q Orth	Spread	LC Mask (hex)	Power/dB	Data	TPC	State
20 | Tr 3	F-DCCH	5.0 ms	9.6 kbps	37	☐	256	0 0	0.00	PRBS	0	OFF
21 | Tr 3	F-FCH	20.0 ms	1.8 kbps	38	☐	256	0 0	0.00	PRBS	0	OFF
22 | Tr 3	F-SCH	20.0 ms	1.8 kbps	39	☐	256	0 0	0.00	PRBS		OFF
23 | Tr 3	F-SCH	20.0 ms	1.8 kbps	40	☐	256	0 0	0.00	PRBS		OFF

CH NO	Type	Frame Length	Data Rate	Walsh	Q Orth	Spread	LC Mask (hex)	Power/dB	Data	TPC	State
24 | Tr 4	F-DCCH	5.0 ms	9.6 kbps	46	☐	256	0 0	0.00	PRBS	0	OFF
25 | Tr 4	F-FCH	20.0 ms	1.8 kbps	47	☐	256	0 0	0.00	PRBS	0	OFF
26 | Tr 4	F-SCH	20.0 ms	1.8 kbps	48	☐	256	0 0	0.00	PRBS		OFF
27 | Tr 4	F-SCH	20.0 ms	1.8 kbps	49	☐	256	0 0	0.00	PRBS		OFF

CH NO
A continuous channel number starting with 0 is shown in the first column. In WinIQSIM, a base station consists of up to 91 code channels depending on the radio configuration. All channels can be set independently of each other.

Type
In this column the type of channel is shown. Depending on the radio configuration, the first up to 19 table lines are assigned to special channels like pilot, sync and paging channels. There are eight traffic channels in addition. A traffic channel is used for transmitting the radio link information, ie for communication with the addressee. The traffic channels consists of a dedicated channel, a fundamental channel and, depending on the radio configuration of up to 7 supplemental channels. The channel type is a pure display parameter and cannot be edited.

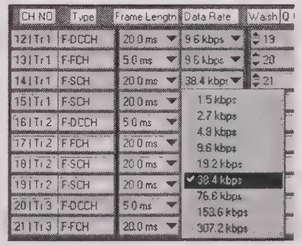
Frame Length
Different frame lengths can be defined depending on channel type and radio configuration. The following frame lengths are supported: 5 ms, 20 ms, 26,6 ms (sync channel only), 40 ms and 80 ms. All these frame lengths are an integral part of the 80 ms frame. For this reason 80 ms was chosen in WinIQSIM as the basic sequence length. The selected frame length in turn influences the possible data rates of a channel.



CH NO	Type	Frame Length	Data Rate
20 | Tr 1	F-FCH	20.0 ms	1.8 kbps
21 | Tr 1	F-SCH		bps
22 | Tr 1	F-SCH		bps
23 | Tr 2	F-DCCH		kbps
24 | Tr 2	F-FCH	20.0 ms	1.8 kbps

Data Rate

Depending on channel type, radio configuration and frame length, different data rates can be chosen for a channel. All data rates between 1.2 kbps and 1,036.8 kbps defined in the standard are supported. The selection of the data rate influences the length of the Walsh code (spreading factor) that can be used for this channel.



CH NO	Type	Frame Length	Data Rate	Walsh
12 | Tr 1	F-DCCH	20.0 ms	9.6 kbps	19
13 | Tr 1	F-FCH	5.0 ms	9.6 kbps	20
14 | Tr 1	F-SCH	20.0 ms	38.4 kbps	21
15 | Tr 1	F-SCH	20.0 ms		
16 | Tr 2	F-DCCH	5.0 ms		
17 | Tr 2	F-FCH	20.0 ms		
18 | Tr 2	F-SCH	20.0 ms		
19 | Tr 2	F-SCH	20.0 ms		
20 | Tr 3	F-DCCH	5.0 ms		
21 | Tr 3	F-FCH	20.0 ms		

Walsh Code
In this column a Walsh code can be assigned to the code channel. The value range of the Walsh code depends on the radio configuration, channel type, frame length and the data rate. With some channels, eg pilot or sync, the Walsh code to be used is specified in the standard. Generally, the Walsh code can only varied within the range specified by the standard.

Quasi Orthogonal Walsh Set
In this column it can be decided for each channel whether the spreading code is taken from the standard Walsh set (field not active ☐) or from the quasi-orthogonal Walsh set (field active ☑) selected for the BS. Depending on the channel type and other parameters, the standard does not allow the use of quasi-orthogonal codes. In this case the selection field is dimmed.

Spreading Factor
In this column the spreading factor of the channel is displayed. The spreading factor corresponds to the length of the Walsh code and depends on parameters like the radio configuration and the data rate. Possible spreading factors are 4, 8, 16, 32, 64, 128 and 256.

LC Mask
Here the mask of the long-code generator can be entered (see 12.1.1.1). The mask is to be indicated in hexadecimal form. The long-code mask is a 42-bit value that can be entered in two parts, as high (10-bit) and low (32-bit) word. The value range is 0 to 3FF FFFF FFFF. The mask serves for channel-specific and user-specific scrambling of the code channel. Depending on the channel type, only certain masks are permitted by the IS2000 standard. For further information refer to [2]. In WinIQSIM the whole value range can be used independent of the channel type. A common long-code mask can only be assigned to a traffic channel and its subchannels. The mask can be entered in the table line of the associated dedicated control channel. This mask is then automatically used by all other subchannels of the traffic channel. The associated entry elements are dimmed.

Power/dB
In this column the power of the code channel can be set. The value range of the channel power is –60 dB to 0 dB.

Data
Selection of one of the four data sources Data 0, Data 1, Data 2 or PRBS. For the definition of data sources see section 7.2.

TPC
A pattern of up to 16 bits can be entered here for transmitter power control (power control puncturing) of the code channel. To this end the data stream is punctured after long-code scrambling at the frequency of 800 Hz and one to six information bits are replaced by a corresponding number of power control bits (0...0 or 1...1). To do so a bit is taken from the TPC pattern and multiplied. The specified bit pattern is used cyclically.

State: In this switch it can be determined whether the code channel is to be contained in the scenario or not. The State buttons of active channels are shown in green. Thus active channels can be seen at a glance.

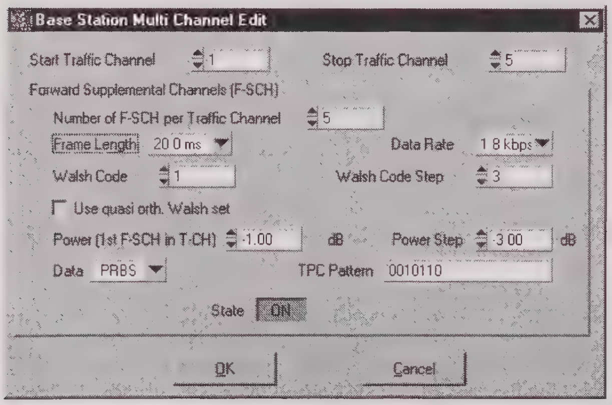
The displayed range can be changed with the scrollbar at the right of the table. The following modes are supported

Table 12-8 Scrollbar modes

Function	Action required
Scrolling through the table line by line	- Switch off page scrolling ☐ Page Scrolling - Click with the mouse on the large arrows ▲, ▼ or - Mark the black box ■ with the mouse -> scrollbar is activated - Press the <Up> / <Down> cursor keys.
Scrolling through the table page by page	- Switch on Page Scrolling" ☑ Page Scrolling - Click with the mouse on the large arrows ▲, ▼
Jumping to any position in the table	- Click with the mouse on the black box ■ (keep key pressed) - Move to desired position - Release left mouse key

12.2.2.5.3 Multi Channel Edit

Pressing the Multi Channel Edit button opens a window where several traffic channels can be configured.



Base Station Multi Channel Edit

Start Traffic Channel 1

Stop Traffic Channel 5

Forward Supplemental Channels (F-SCH)

Number of F-SCH per Traffic Channel 5

Frame Length 20.0 ms

Data Rate 1.8 kbps

Walsh Code 1

Walsh Code Step 3

☐ Use quasi orth. Walsh set

Power (1st F-SCH in T-CH) -1.00 dB

Power Step -3.00 dB

Data PRBS

TPC Pattern 0010110

State ON

Fig. 12-23 Base Station Multi Channel Edit panel

In this window all parameters of the associated supplemental (sub)channels can be set for a group of traffic channels. The channel parameter value ranges correspond to the associated parameters in the channel table (see above).

Start Traffic Channel/Stop Traffic Channel: The range of the traffic channels to be set together is defined here.

In the following panel window the forward supplemental (sub)channels of the individual traffic channels are configured.

In the **Number of F-SCH per Traffic Channel** field, the number of supplemental channels contained in each traffic channel is defined. The value range of 1 to max. 7 depends on the radio configuration.

The frame length and the data rate of the channels is selected next. To be able to set complete channel scenarios, start values and step widths can be entered for some parameters to set the channel parameters. The **Walsh code and Walsh Code Step** parameters can for example be used to create simple scenarios. Spreading codes with a fixed step width are assigned to the individual code channels. In the **Use quasi orth. Walsh set** field you decide whether the Walsh codes should be taken from the standard set or from the quasi-orthogonal set selected for the BS. With **Power** and **Power Step**, power profiles (on the code channel axis) can be generated in the same way as the Walsh codes.

When **OK** is pressed, the channel table is completed with the values defined in the panel. **Cancel** aborts the changes made in the settings.

12.2.2.5.4 Reset BS Table

The reset button is used to reset the channel table parameters of the base station to defined settings. The parameters described in section 12.2.2.5.1, Common Base Station Settings, are not effected. The reset values are shown in the following table.

Table 12-9 Reset values of BS table

Parameters of code channels	**Reset value**
Frame length	Dep. on channel type, 20 ms if possible, otherwise lowest possible frame length.
Data rate	Dep. on channel type, 9.6 kbps if possible, otherwise lowest possible data rate
Walsh code	Dep. on channel type, channel number in the table, otherwise lowest possible Walsh code
Quasi-orth. spreading	Off for all channels
Long-code mask	0 for all channels
Power	0 dB for all channels
Data source	PRBS for all channels
TPC pattern	0 for all channels
State	Off for all channels

12.2.2.5.5 Channel Graph

This graph gives an overview of all active channels.

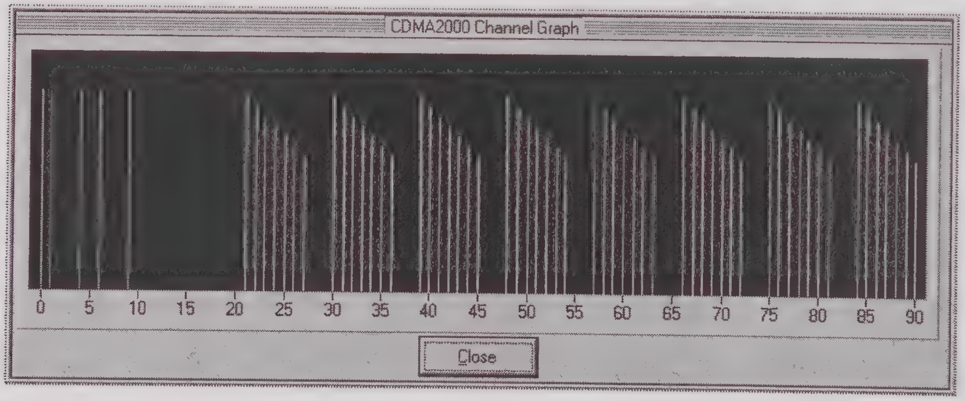
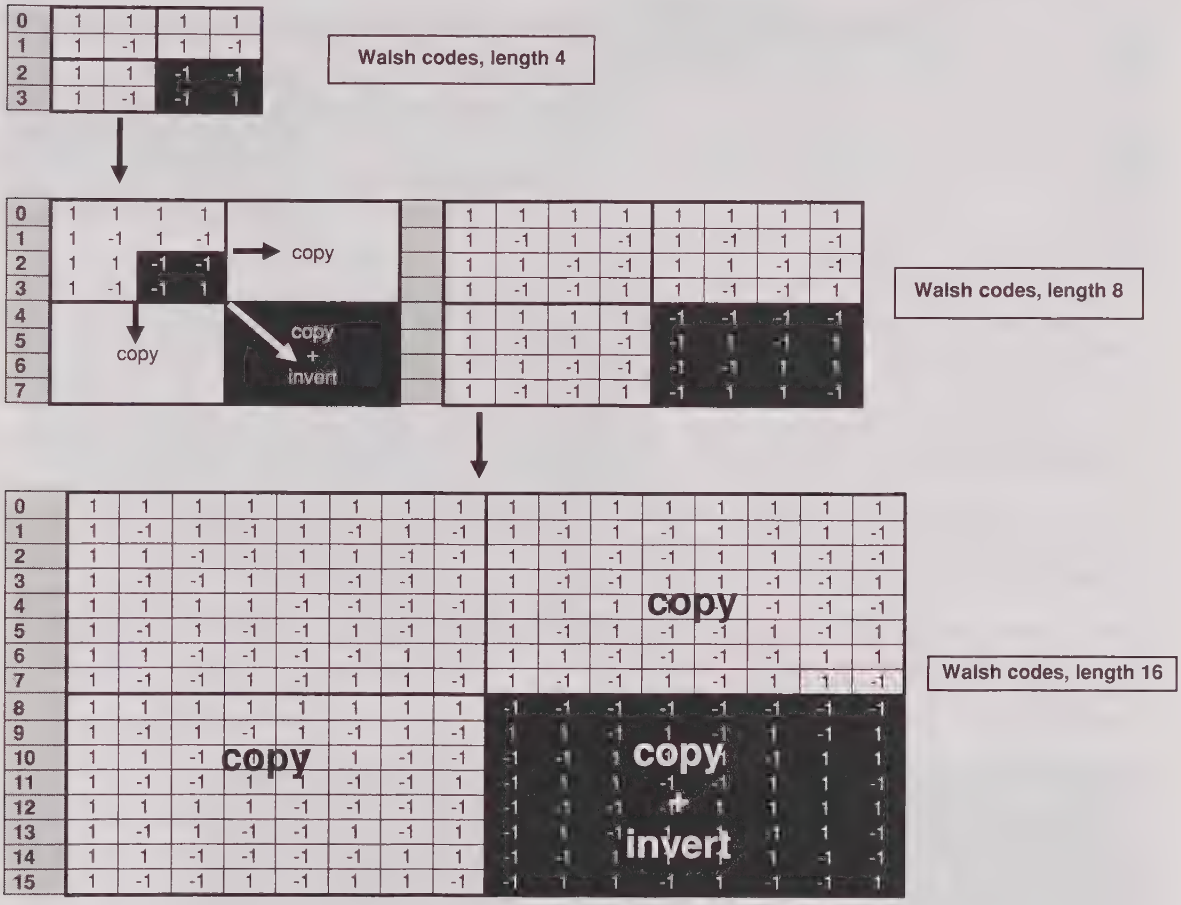


Fig. 12-24 Channel graph

Special channels and traffic channels are coloured as described in section 12.2.2.5.2 The channel power can be seen from the length of the line. The channel graph can be displayed simultaneously with the other windows. Thus, modifications in the channel table affecting the channel graph can be seen at a glance.

12.2.2.5.6 Code Domain

The Walsh codes of variable length used by CDMA2000 are the so-called Hadamard codes.
The structure of these codes is explained below. The code matrix of the order N+1 is obtained from the matrix N by extending the latter to the right and downwards through copying and to the left by copying and inversion (see below).



0	1	1	1	1
1	1	-1	1	-1
2	1	1	-1	-1
3	1	-1	-1	1

0	1	1	1	1	1	1	1	1
1	1	-1	1	-1	1	-1	1	-1
2	1	1	-1	-1	1	1	-1	-1
3	1	-1	-1	1	1	-1	-1	1
4	1	1	1	1	-1	-1	-1	-1
5	1	-1	1	-1	-1	1	-1	1
6	1	1	-1	-1	-1	-1	1	1
7	1	-1	-1	1	-1	1	1	-1

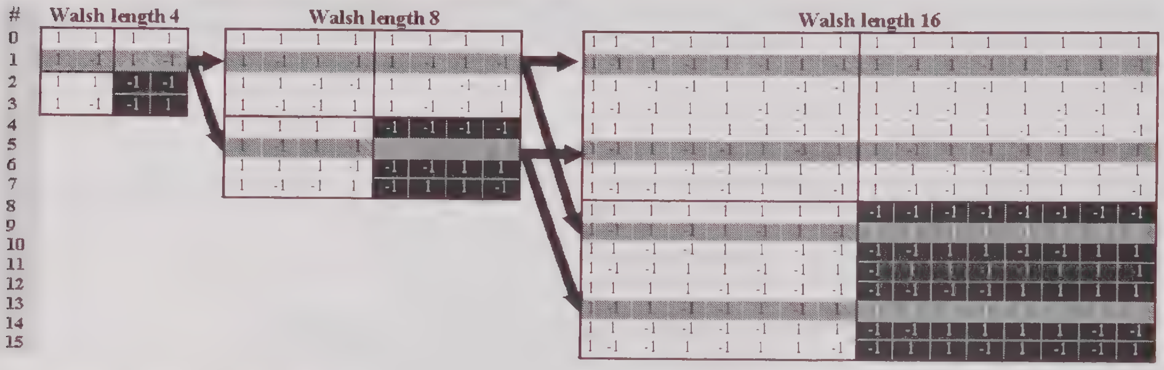
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1
2	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1
3	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1
4	1	1	1	1	-1	-1	-1	-1	1	1	1	[illegible]	[illegible]	-1	-1	-1
5	1	-1	1	-1	-1	1	-1	1	1	-1	1	-1	-1	1	-1	1
6	1	1	-1	-1	-1	-1	1	1	1	1	-1	-1	-1	-1	1	1
7	1	-1	-1	1	-1	1	1	-1	1	-1	-1	1	-1	1	1	-1
8	1	1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1
9	1	-1	1	-1	1	-1	1	-1	-1	1	-1	1	-1	1	-1	1
10	1	1	-1	[illegible]	[illegible]	1	-1	-1	-1	-1	1	[illegible]	[illegible]	-1	1	1
11	1	-1	-1	1	1	-1	-1	1	-1	1	1	-1	-1	1	1	-1
12	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	[illegible]	1	1	1	1
13	1	-1	1	-1	-1	1	-1	1	-1	1	-1	[illegible]	[illegible]	-1	1	-1
14	1	1	-1	-1	-1	-1	1	1	-1	-1	1	[illegible]	[illegible]	1	-1	-1
15	1	-1	-1	1	-1	1	1	-1	-1	1	1	-1	1	-1	-1	1

Fig. 12-25 Generation scheme of Walsh code

Walsh codes of the lengths 4, 8, 16, 32, 64, 128 and 256 are used in CDMA2000. The greater the spreading factor / Walsh code length, the smaller the useful symbol rate prior to spreading and vice versa. The Walsh codes and their generation scheme are closely related to the spreading codes of 3GPP. Basically, the same spreading sequences are used, only the order in the respective code trees is different. To find a 3GPP code that corresponds to a CDMA2000 code, the bit-inverted line (line index) has to be selected in the 3GPP matrix of identical spreading factor.

Example: *The 3GPP spreading code matching line 10 of the 16-bit Walsh code matrix is searched for. The binary form of the line index 10 (with 4 bits, because of Walsh length 16 = 2^4) is 1010. The bit-inverted index is 0101, ie 5 in decimal notation. This means that the Walsh code No. 10 with the length 16 corresponds to the 3GPP spreading code 5 of the same length (spreading factor).*

In contrast to the spreading codes of 3GPP, Walsh codes of short lengths (low spreading factor) do not occupy a block area in a Walsh matrix of larger spreading factor. Several lines (ratio of the two spreading factors) are occupied in the matrix with a higher spreading factor, distributed over the whole matrix. This behaviour is illustrated in the diagram below. This results from the structuring scheme of the Walsh codes that are obtained by copying and inverting the next smaller matrix.



#	Walsh length 4			
0	1	1	1	1
1	1	-1	1	-1
2	1	1	-1	-1
3	1	-1	-1	1

#	Walsh length 8							
0	1	1	1	1	1	1	1	1
1	1	-1	1	-1	1	-1	1	-1
2	1	1	-1	-1	1	1	-1	-1
3	1	-1	-1	1	1	-1	-1	1
4	1	1	1	1	-1	-1	-1	-1
5	1	-1	1	-1				
6	1	1	1	-1	-1	-1	1	1
7	1	-1	-1	1	-1	1	1	-1

#	Walsh length 16															
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1
2	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1
3	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1
4	1	1	1	1	1	1	-1	-1	1	1	1	1	-1	-1	-1	-1
5	1	-1	1	-1	-1	1	-1	1	1	-1	1	-1	-1	1	-1	1
6	1	1	1	-1	-1	-1	1	1	1	1	-1	-1	-1	-1	1	1
7	1	-1	-1	1	-1	1	1	-1	1	-1	-1	1	-1	1	1	-1
8	1	1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1
9	1	-1	1	-1	1	-1	1	-1								
10	1	1	-1	-1	1	1	-1	-1	-1	-1	1	1	-1	-1	1	1
11	1	-1	-1	1	1	-1	-1	1	-1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1
12	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	1	1	1	1
13	1	-1	1	-1	-1	1	-1	1								
14	1	1	-1	-1	-1	-1	1	1	-1	-1	1	1	1	1	-1	-1
15	1	-1	-1	1	-1	1	1	-1	-1	1	1	-1	1	-1	-1	1

Fig. 12-26 Walsh code tree

If a Walsh code with the length 4 and index 1 is used, codes 1 and 5 are disabled at the length 8, and codes 1, 4, 9 and 13 at the length 16 because codes of greater length contain the output code of shorter length (or its inversion).

When using such conflicting Walsh codes simultaneously, the signals of the associated code channels are mixed so that they can no longer be separated in the receiver. Orthogonality will then be lost.

The matrix range with the highest spreading factor (ie 256), which is based on the spreading code selected in the code tree, is then defined as **domain** of a specific Walsh spreading code. Using a spreading code means that its entire domain is used.

When pressing the **Code Domain** button, a graph is opened that shows the assignment of active code channels in the code domain. Since a quasi-orthogonal Walsh set is available for the Walsh set and for every base station, the code domain display contains two windows. In the upper window the code domain of the standard Walsh set is displayed, in the lower window the quasi-orthogonal Walsh sets.

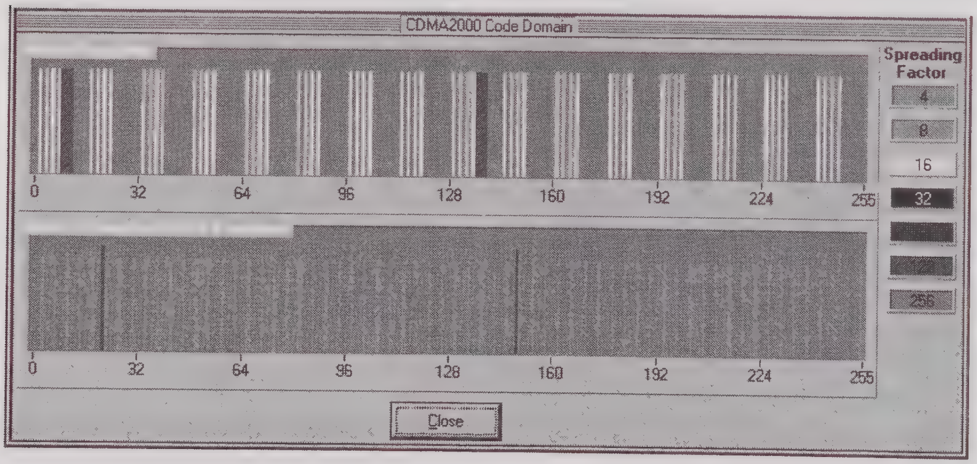
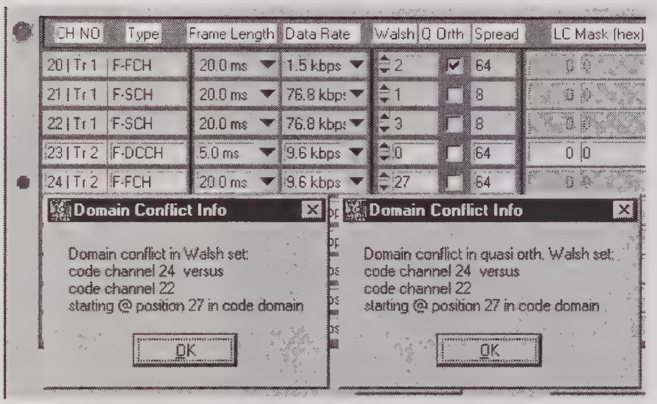


Fig. 12-27 Code domain display

In this display assignment of the domains can be seen at a glance. Compared to 3GPP it is however much more difficult to see whether the code domains of different channels overlap, ie whether there is a domain conflict. This is due to the structure of the Walsh codes described above. The reason is that no block areas are occupied in the domain but several areas of minimum width are distributed over the whole domain.

The spreading factors of the code channels can be identified by the colour of the associated bars. The legend at the right of the graph indicates the assignment of colours to the spreading factors. The height of the bars indicates the power of the code channel.
The code domain graph can be displayed simultaneously with the other windows. Thus, modifications in the channel table affecting the code domain graph can be seen immediately.

Display of domain conflicts
If a domain conflict occurs in the base station, an LED lights up in front of the channel line in the table. All lines in the channel table (lines processed in ascending order of channel numbers) having a domain conflict with a line of a lower index are marked by a red LED at the left of the channel number.
A domain conflict occurs when the occupied domains of different channel lines overlap.
A click on one of the red LEDs with the left mouse key opens a window where more detailed information on the domain conflict is given. In addition to the information on conflicting code channels and whether the conflict has occurred in the Walsh set or the quasi-orthogonal Walsh set, the first domain area where the two code channels overlap is displayed.



●	CH NO	Type	Frame Length	Data Rate	Walsh	Q Orth	Spread	LC Mask (hex)
	20 | Tr 1	F-FCH	20.0 ms	1.5 kbps	2	☑	64	0 0
	21 | Tr 1	F-SCH	20.0 ms	76.8 kbp	1	☐	8	0 0
	22 | Tr 1	F-SCH	20.0 ms	76.8 kbp	3	☐	8	0 0
	23 | Tr 2	F-DCCH	5.0 ms	9.6 kbps	0	☐	64	0 0
●	24 | Tr 2	F-FCH	20.0 ms	9.6 kbps	27	☐	64	0 0

Domain Conflict Info

Domain conflict in Walsh set:
code channel 24 versus
code channel 22
starting @ position 27 in code domain

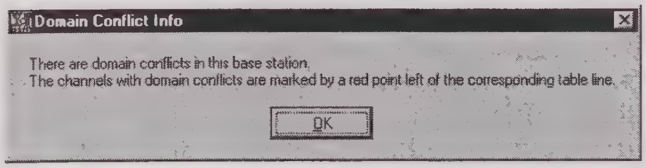
Domain Conflict Info

Domain conflict in quasi orth. Walsh set:
code channel 24 versus
code channel 22
starting @ position 27 in code domain

Fig. 12-28 Display of domain conflict info

Using this display as a basis, the domain conflicts can be resolved with the aid of the code domain display starting from the lowest channel number.

In addition to the headline of the channel table, an LED informs whether domain conflicts occur in the whole base station (red LED: ●) or not (green LED: ●). It is thus possible to see whether channel lines that are not in the displayed table area lead to conflicts. A click with the left mouse key on this display opens the following window.



Domain Conflict Info

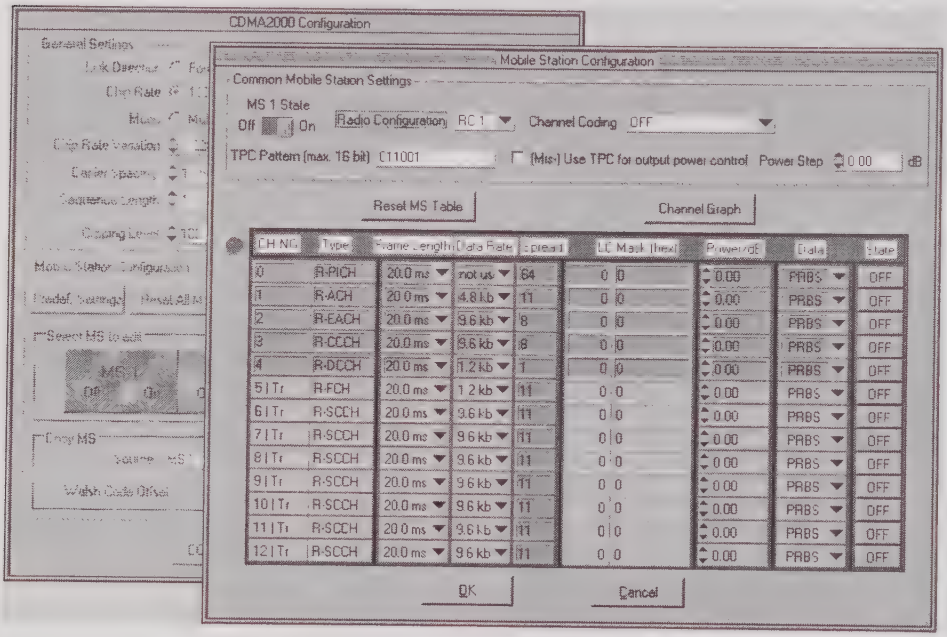
There are domain conflicts in this base station.
The channels with domain conflicts are marked by a red point left of the corresponding table line.

Fig. 12-29 Domain conflict info

The Base Station Configuration panel is quit by pressing the **OK** button. When the **Cancel** button is pressed, all changed settings are discarded.

12.2.2.6 Mobile Station Configuration

A click on one of the mobile station blocks in the CDMA2000 Configuration panel opens the Mobile Station Configuration panel. The CDMA2000 Configuration panel is also displayed but it is dimmed since the two windows are interrelated in many ways. The CDMA2000 configuration parameters can still be read but not changed. When the Mobile Station Configuration panel is closed (with OK or Cancel), the CDMA2000 Configuration panel is enabled again.



MS 1 State Off ▨ On
Radio Configuration RC 1
Channel Coding OFF
TPC Pattern (max. 16 bit) 011001
☐ (Mis-) Use TPC for output power control
Power Step 0.00 dB

CH NO	Type	Frame Length	Data Rate	Spread	LC Mask (hex)	Power/dB	Data	State
0	R-PICH	20.0 ms	not us	64	0 0	0.00	PRBS	OFF
1	R-ACH	20.0 ms	4.8 kb	11	0 0	0.00	PRBS	OFF
2	R-EACH	20.0 ms	9.6 kb	8	0 0	0.00	PRBS	OFF
3	R-CCCH	20.0 ms	9.6 kb	8	0 0	0.00	PRBS	OFF
4	R-DCCH	20.0 ms	1.2 kb	1	0 0	0.00	PRBS	OFF
5 | Tr	R-FCH	20.0 ms	1.2 kb	11	0 0	0.00	PRBS	OFF
6 | Tr	R-SCCH	20.0 ms	9.6 kb	11	0 0	0.00	PRBS	OFF
7 | Tr	R-SCCH	20.0 ms	9.6 kb	11	0 0	0.00	PRBS	OFF
8 | Tr	R-SCCH	20.0 ms	9.6 kb	11	0 0	0.00	PRBS	OFF
9 | Tr	R-SCCH	20.0 ms	9.6 kb	11	0 0	0.00	PRBS	OFF
10 | Tr	R-SCCH	20.0 ms	9.6 kb	11	0 0	0.00	PRBS	OFF
11 | Tr	R-SCCH	20.0 ms	9.6 kb	11	0 0	0.00	PRBS	OFF
12 | Tr	R-SCCH	20.0 ms	9.6 kb	11	0 0	0.00	PRBS	OFF

Fig. 12-30 Mobile Station Configuration panel

12.2.2.6.1 Common Mobile Station Settings

In this section the parameters valid for the complete mobile station can be set.

MS State: The complete mobile station can be switched on or off.

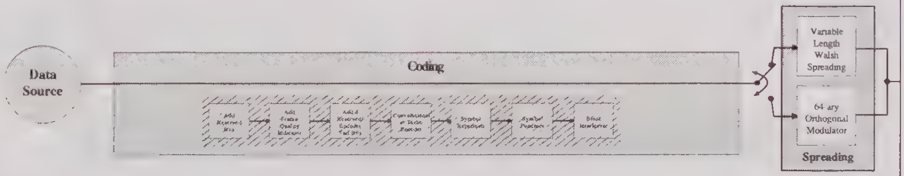
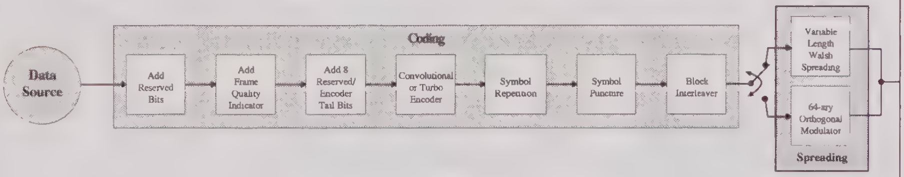
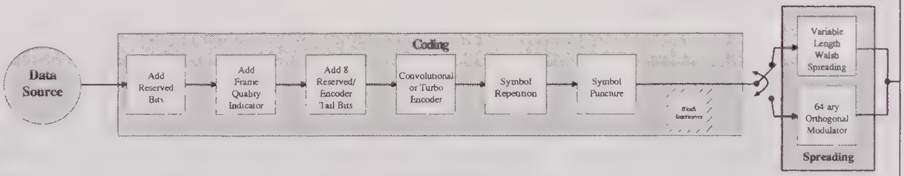
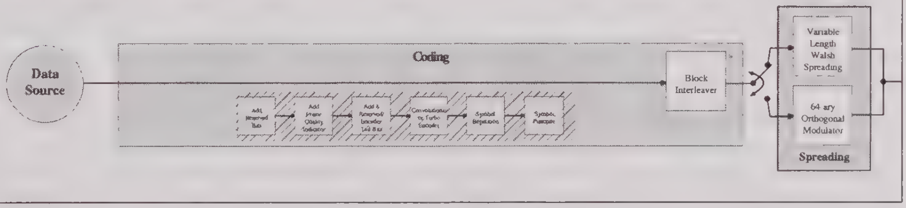
Radio Configuration

The radio configuration parameter is comparable with selecting the rate sets of IS-95. The radio configuration influences the whole structure of the channel table. It determines among other things the defined channel types and the frame lengths and data rates that can be used. Depending on the spreading rate, the following radio configurations can be set.
Spreading rate 1X: RC1 – RC4
Spreading rate 3X: RC5 – RC6

Channel coding

With this parameter you can decide whether the code channels of the mobile station should be channel-coded or not. Channel coding is performed as described in section 12.1.1.2. Depending on channel type and radio configuration, blocks like **Add Reserved Bits** may not be available. To test also individual components of the channel coding in your receiver, four coding modes are offered which are explained in the table below.

Table 12-10 Channel coding modes

Coding mode	Function / structure
Off	Channel coding is not performed. The data sources of the individual channels apply their data stream directly to the spreader. The data source supplies the traffic data with the data rate that would be available at the spreader after coding is switched on. The data rate parameter shown in the channel table is no longer valid.  Data Source Coding Variable Length Walsh Spreading 64 ary Orthogonal Modulator Spreading
Complete	The complete channel coding (see 12.1.1.1) is performed.  Data Source Coding Add Reserved Bits Add Frame Quality Indicator Add 8 Reserved/ Encoder Tail Bits Convolutional or Turbo Encoder Symbol Repetition Symbol Puncture Block Interleaver Variable Length Walsh Spreading 64-ary Orthogonal Modulator Spreading
Without Interleaving	Except for the block interleaver, the whole channel coding procedure is carried out. In this mode the frame structure and the convolutional coder of your receiver can be tested.  Data Source Coding Add Reserved Bits Add Frame Quality Indicator Add 8 Reserved/ Encoder Tail Bits Convolutional or Turbo Encoder Symbol Repetition Symbol Puncture Block Interleaver Variable Length Walsh Spreading 64 ary Orthogonal Modulator Spreading
Interleaving Only	In this mode only block interleaver is used for coding. This allows the deinterleaver in the receiver to be tested independently of the remaining (de-)coding process.  Data Source Coding Block Interleaver Variable Length Walsh Spreading 64 ary Orthogonal Modulator Spreading

TPC

In this field a pattern of maximum 16 bits can be specified. In WinIQSIM this parameter is used exclusively for controlling the mobile station output power (see description below). In the reverse link, power control puncturing or a similar function is not defined for controlling the base station power. The specified bit pattern is used cyclically.

(Mis-)Use TPC for output power control / Power Step:

If the **(Mis-)Use TPC** option is active, the specified pattern is used to vary the output power as a function of time. Every 1.25 ms (800 Hz), a bit of this pattern is used to increase (bit = 1) or decrease (bit = 0) the power of all code channels by the specified power step. The upper limit is 0 dB, the lower limit -60 dB.

The following envelope is obtained at a channel power of 0 dB, power step of 1.0 dB and the pattern 0011001100000011:

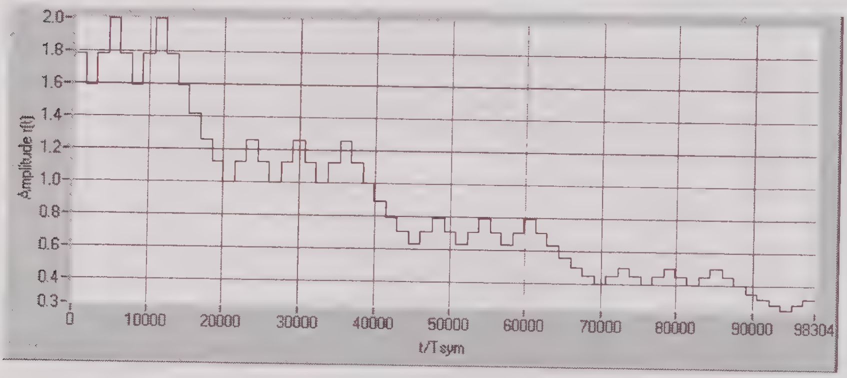


Fig. 12-31 Dynamic change of channel power

Note that the first bit is assigned to the first power control section. In this first section the start power specified in the channel table is always used, ie only in the next power control section (with the second TPC bit) will the defined power change be effective.

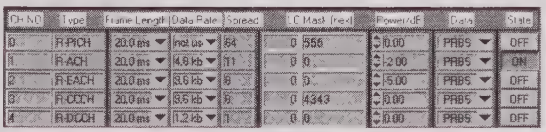
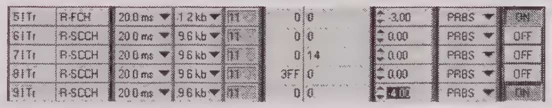
12.2.2.6.2 Channel Table of Mobile Station

Most of the Mobile Station Configuration panel is taken up by the channel table. The table elements can be directly edited or changed. The individual parameters in the table columns that can be changed are described in the following.

Basic table structure:
Two different classes of channels are available in the CDMA2000 reverse link. There are channels like the reverse pilot and reverse dedicated control channels containing control information. These channels are called **special channels**. Dedicated channels are also defined that contain information for the recipient. These channels are called **traffic channels**. In the reverse link, the channel scenario with the spreading codes of the individual channels is predefined by selecting the radio configuration. For this reason the channel table does not contain selection parameters for the Walsh code. Depending on the radio configuration, a mobile may occupy up to 13 code channels. Some channels like the reverse common control channel (R-CCCH) and the enhanced access channel (R-EACH) may only be used alternatively according to the standard. This restriction does not exist in WinIQSIM in order not to complicate the channel table with a settable channel type parameter. For more details on channel combinations see [2].

To show the assignment of the channels to the different groups and for the sake of clarity, the lines of the channel table are displayed in different colours depending on the group to which the channel belongs.

Table 12-11 Assignment of channel groups in the channel table

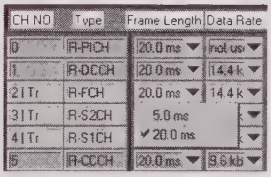
Kanal Gruppe	**Darstellung in der KanalTable**
Sonderkanäle	
Traffic Channel	

CH NO	Type	Frame Length	Data Rate	Spread	LC Mask (hex)		Power/dB	Data	State
0	R-PICH	20.0 ms	not us	64	0	555	0.00	PRBS	OFF
1	R-ACH	20.0 ms	4.8 kb	11	0	0	-2.00	PRBS	ON
2	R-EACH	20.0 ms	9.6 kb	8	0	0	-5.00	PRBS	OFF
3	R-CCCH	20.0 ms	9.6 kb	8	0	4343	0.00	PRBS	OFF
4	R-DCCH	20.0 ms	1.2 kb	1	0	0	0.00	PRBS	OFF
5 | Tr	R-FCH	20.0 ms	1.2 kb	11	0	0	-3.00	PRBS	ON
6 | Tr	R-SCCH	20.0 ms	9.6 kb	11	0	0	0.00	PRBS	OFF
7 | Tr	R-SCCH	20.0 ms	9.6 kb	11	0	14	0.00	PRBS	OFF
8 | Tr	R-SCCH	20.0 ms	9.6 kb	11	3FF	0	0.00	PRBS	OFF
9 | Tr	R-SCCH	20.0 ms	9.6 kb	11	0	0	-4.00	PRBS	ON

CH NO
A continuous channel number starting with 0 is shown in the first column. A base station in WinIQSIM consists of up to 13 code channels depending on the radio configuration. All channels can be set independently of each other.

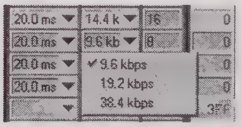
Type
In this column the type of channel is shown. The first channels in the table are the special channels. They are followed by the traffic channels. Sometimes the block of traffic channels is followed by another block of special channels. The channels sequence and thus the table structure largely complies with the channel scenario for the reverse link specified in the standard. The channel type is a pure display parameter and cannot be edited.

Frame length
Different frame lengths can be defined depending on channel type and radio configuration. The following frame lengths are supported: 5 ms, 10 ms and 20 ms. All these frame lengths are an integral part of the 20 ms frame. To be compatible with the forward link, 80 ms is also chosen in the reverse link as a basic unit for the sequence length. The selected frame length in turn influences the possible data rates of a channel.



CH NO	Type	Frame Length	Data Rate
0	R-PICH	20.0 ms	not us
1	R-DCCH	20.0 ms	14.4 k
2 | Tr	R-FCH	20.0 ms	14.4 k
3 | Tr	R-S2CH	5.0 ms	
4 | Tr	R-S1CH	✓ 20.0 ms	
5	R-CCCH	20.0 ms	9.6 kb

Data rate
Depending on the channel type, radio configuration and frame length, different data rates can be chosen for a channel. All data rates specified in the standard are supported. The selected data rate influences the Walsh code length (spreading factor).



20.0 ms	14.4 k	16	0
20.0 ms	9.6 kb	8	0
20.0 ms	✓ 9.6 kbps		0
20.0 ms	19.2 kbps		0
	38.4 kbps		3FF

Spreading Factor
In this column the spreading factor of the channel is displayed. The spreading factor corresponds to the length of the employed Walsh code. The Walsh codes to be used are specified by the standard and cannot be chosen.

LC Mask
Here the mask of the long-code generator can be given (see 12.1.1.1). The mask is to be indicated in hexadecimal form. The long-code mask is a 42-bit value that can be entered in two parts, as a high and a low word. The value range is 0 to 3FF FFFF FFFF. The mask serves for channel-specific and user-specific scrambling of the code channel. Depending on the channel type, only certain masks are permitted by the IS2000 standard. For further information refer to [2]. In WinIQSIM the whole value range can be used independently of the channel type.

Power/dB
In this column the power of the code channel can be set. The value range of the channel power is –60 dB to 0 dB.

Data
Selection of one of the four data sources Data 0, Data 1, Data 2 or PRBS.
For the definition of data sources see section 7.2.

State
With this switch it can be determined whether the code channel is to be contained in the scenario or not. The State buttons of active channels are shown in green. Thus active channels can be seen at a glance.

12.2.2.6.3 Reset BS Table

The reset button is used to reset the channel table of the mobile station to defined settings. The parameters described in section 12.2.2.5.1, Common Base Station Settings, are not affected. The reset values are shown in the following table.

Table 12-12 Reset values of BS table

Parameters of code channels	**Reset value**
Frame length	Dep. on channel type, 20 ms if possible, otherwise lowest possible frame length.
Data rate	Dep. on channel type, 9.6 kbps if possible, otherwise lowest possible data rate
Long-code mask	0 for all channels
Power	0 dB for all channels
Data source	PRBS for all channels
State	Off for all channels

12.2.2.6.4 Channel Graph

This graph shows all active channels at a glance.

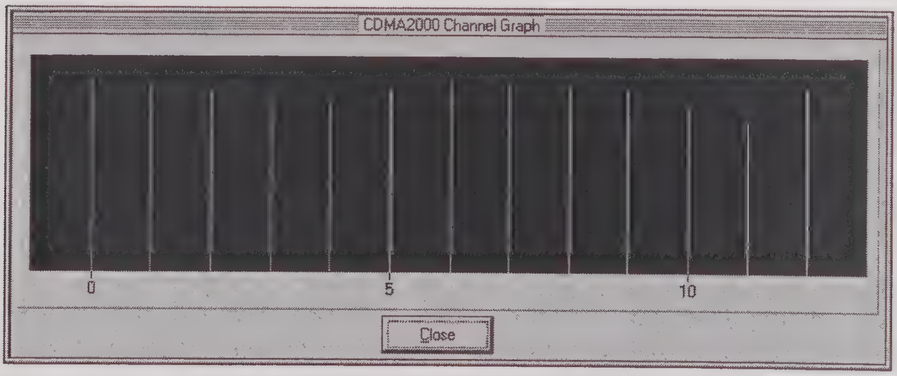


Fig. 12-32 Channel graph

Special channels and traffic channels are coloured as described in section **0** The channel power can be seen from the length of the line. The channel graph can be displayed simultaneously with the other windows. Thus, modifications in the channel table having an effect on the channel graph can be seen at a glance.

The Mobile Station Configuration panel is quit with the **OK** button as usual. When the Cancel button is pressed, the window is cleared and all new settings are discarded.

12.3 Further Information for the Generation of CDMA2000 Signals

This section provides background information on CDMA2000 signals and is intended to make the generation of user-specific signals easier.

12.3.1 CDMA2000 Signale in Zeit- und Frequenzbereich

12.3.1.1 Time Domain

The constellation display should be opened for analyzing the timing characteristic of a CDMA2000 baseband signal. The following graph gives an overview of the CDMA2000 basic constellation for one channel and below for two channels of the same type.

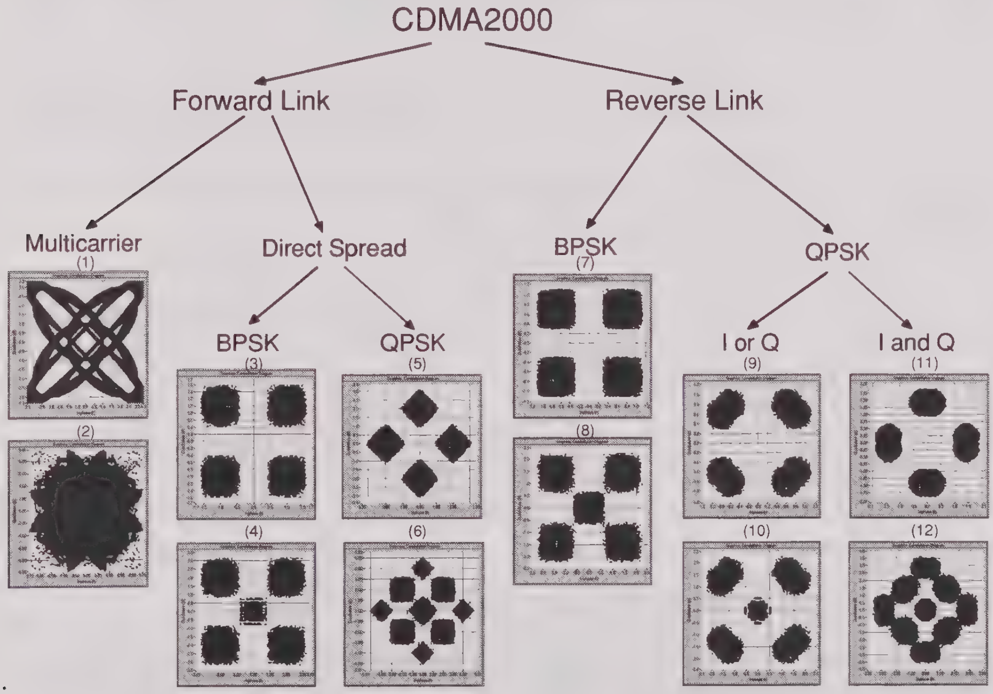


Fig. 12-33 Selection of CDMA2000 system

For the constellation it is assumed that all channels are generated with a power of 0 dB. Except for the multicarrier branch, all constellations have been created with the standard-conformal CDMA2000 1X filter.

12.3.1.1.1 Multicarrier

Because of the frequency shift of the two outer carriers, the corresponding subconstellations are quickly turned round. The ratio of the carrier spacing and the chip clock determines the appearance of the constellation. The two constellations (1) and (2) shown in Fig. 12-33 were obtained by squarewave filtering. When other standard filters (CDMA2000 1X) are used, the constellation normally occupies the complete I/Q layer, ie the structures are no longer recognized.

12.3.1.1.2 Direct Spread

With CDMA2000, a great number of basic constellations can be distinguished depending on the link direction and channel type. The terms BPSK and QPSK in **Fig. 12-33** refer to data modulation. BPSK means that a bit of each symbol clock is spread and that the real spreading signal is scrambled with the PN short code. This method is used with all channels that have been taken from or are based on the preceding IS-95 system. These are:

- Pilot, sync and paging channels (forward link)
- Fundamental and supplemental code channels (RC1 and RC2 in the forward link)
- Access channel (reverse link)
- Fundamental and supplemental code channels (RC1 and RC2 in the forward link)

QPSK modulation means that two bits per symbol clock of a source are spread in parallel and that the complex spreading signal is then scrambled with the complex PN short code.

Forward Link

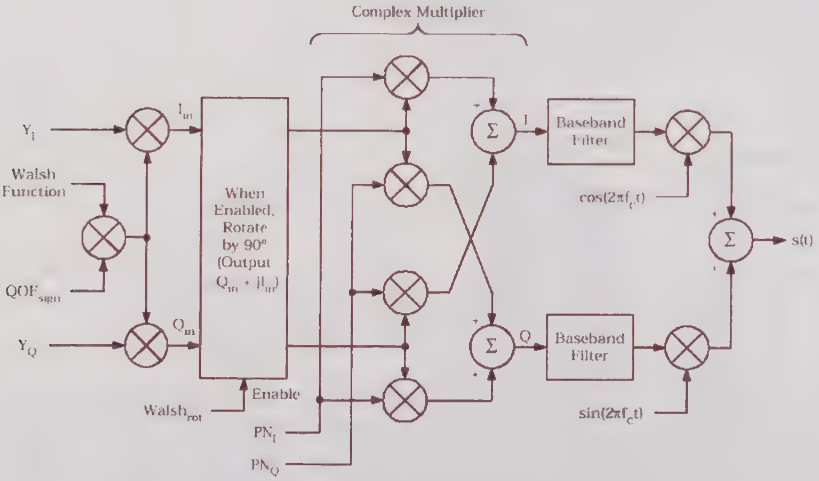


Fig. 12-34 Spreading scheme in the forward link direct spread mode (OTD off)

In this diagram, all data lines Y_i, Y_Q, PN_i, PN_Q and the Walsh functions may assume the states +1 or -1. If necessary, the 0 and 1 states are mapped to +1 and -1.
Control lines QOF_{sign} and $Walsh_{rot}$ are considered inactive in the following.

Im Forward Link wird BPSK- und QPSK Datenmodulation verwendet.

BPSK and QPSK modulation are used in the forward link.

With BPSK, the Y_Q input line is not used. Spreading with (+1/-1) Walsh sequences using the (+1/-1) input data stream Yi creates chips that may in turn have the values +1 or -1.
By scrambling with +/-1 PN sequences, the typical single-channel BPSK mapping (3) with the points { (-1, -1), (-1,+1), (+1, -1), (+1, +1) } is obtained.
If two channels are spread according to this scheme, the same or opposite chip values may occur at any time at the output of the Walsh spreader in the two channels. When compared with the single-channel case (3), identical values create a point of identical phase and twice the amplitude. Opposite values result in cancellation.
As can be seen in Fig. 12-33 (4), a five-point constellation is thus obtained.

With QPSK modulation, modulation data are applied to lines Y_i and Y_Q. The complex multiplication of the complex spreader output signal (I and Q component in the value range +1/-1) by the PN sequence yields a 4-point constellation (5) { (-2, 0), (+2, 0), (0, -2), (0, +2) }. In contrast to the single-channel constellation of BPSK (3), this constellation is turned by 45° and amplified by a factor of 2.
If two channels are spread according to this scheme, the following four cases may occur any time at the output of the Walsh spreader:

1. Identical I and Q components in the two channels: same as in the single channel mode (5), but with twice the amplitude (->4 points at { (-4, 0), (+4, 0), (0, -4), (0, +4)).
2. Opposite I and Q components in the two channels: complete cancellation (-> point at (0,0)).
3. I components identical, Q components opposite: cancellation of Q component, therefore same as with two-channel BPSK (4) (-> 4 points at { (-2, -2), (-2,+2), (+2, -2), (+2, +2)).
4. I components opposite, Q components identical: cancellation of I component, therefore same as with two-channel BPSK (4) (-> 4 points at { (-2, -2), (-2,+2), (+2, -2), (+2, +2)).

As can be seen in Fig. Fig. 12-33, a 9-point constellation is created (6).

Reverse link

BPSK (data-modulated) channels are spread with a scheme similar to that in the forward link. The scheme also creates identical constellations (7) = (3), (8) = (4).

Spreading scheme for channels using **QPSK** modulation:

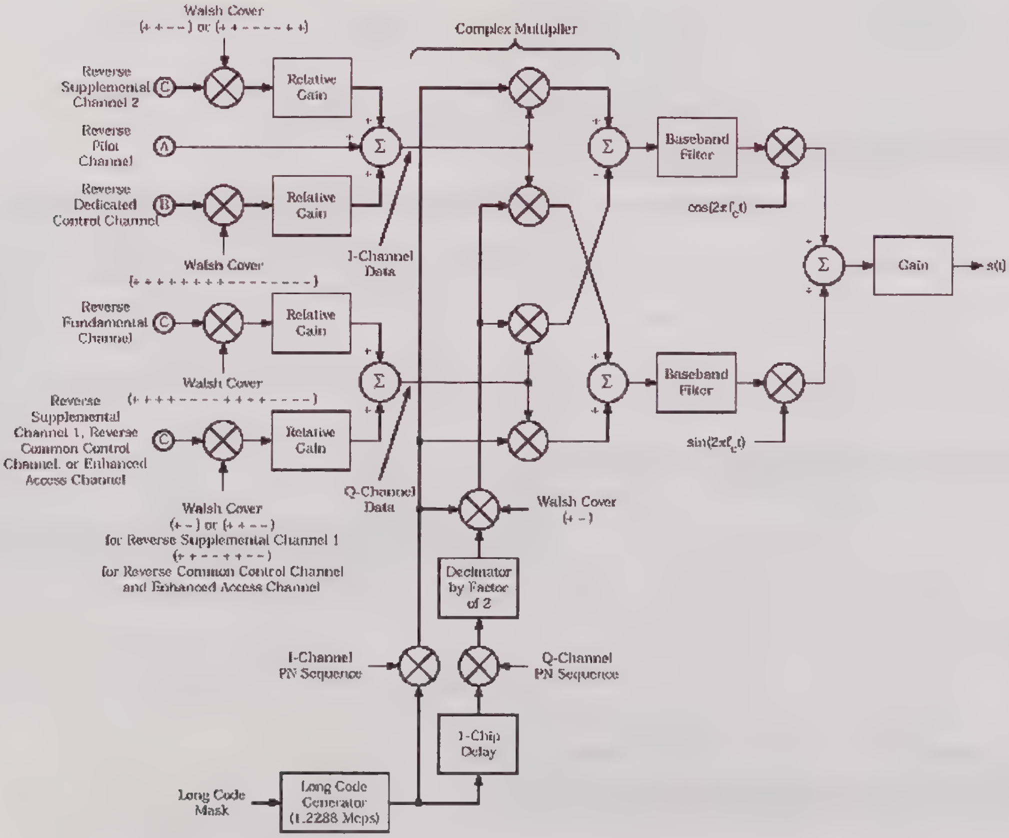


Fig. 12-35 Spreading scheme in the reverse link for QPSK-modulated channels

The term QPSK modulation refers to the option that I and Q lines can assume the values (+1/-1) prior to complex scrambling with the PN sequence.
One channel is always set to I or Q only. If the second line is not used (I or Q subtree in Fig. 12-33, (9) and (10)), a similar constellation as with BPSK is obtained. Because of the skillful modification of PN sequences (HPSK), only 50% of all zero crossings are eliminated. This leads to a distortion of the constellation ranges.
If the two lines are occupied by channels of identical power (I and Q, (11) and (12)), the constellation is identical to that obtained in the forward link with QPSK. The difference is again a distortion of the constellation ranges.

12.3.1.2 Frequency Range

12.3.1.2.1 Forward Link, 1X Mode

The filter specified in [2], section 3.1.3.1.14.1.1, is included as CDMA2000 1X filter in the filter panel. The following spectrum is obtained:

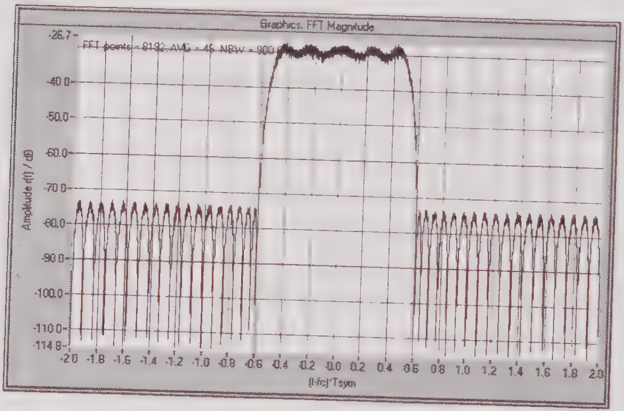


Fig. 12-36 Spreading scheme in the reverse link for QPSK-modulated channels

A characteristic feature is the ripple in the passband and the relatively low attenuation in the stopband.

The resulting ACP value is approx. -34 dB.

A better ACP value (with poorer EVM) is obtained with the "cdma_705.ifl" filter installed together with WinIQSIM, which can be included as user filter in the filter panel:

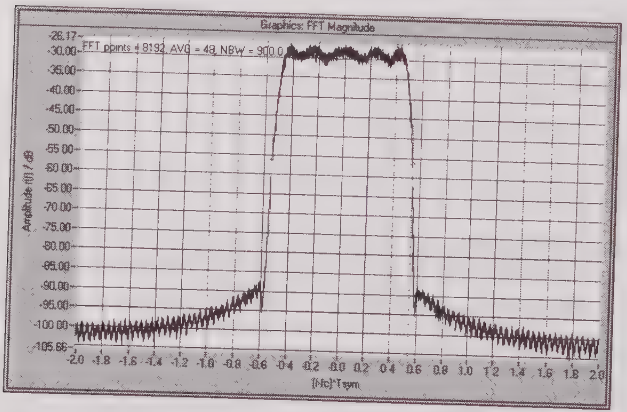


Fig. 12-37 Spectrum of magnitude of CDMA2000 1X signal with special, low ACP filter

This reduces the ACP value to -52 dB.

12.3.1.2.2 Forward Link, 3X Mode (Direct Spread)

The filter specified in [2], section 3.1.3.1.14.2.1, is included as CDMA2000 1X filter in the filter panel. The following spectrum is obtained:

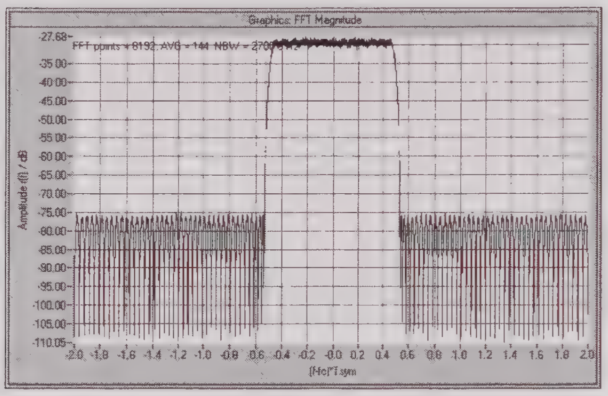


Fig. 12-38 Spectrum of magnitude of CDMA2000 3X signal (direct spread)

This filter is much longer (108 taps) than the 1X filter (48 taps). The result is a higher attenuation in the stopband and a finer ripple.
An ACP value of approx. -49 dB can thus be achieved.

12.3.1.2.3 Forward Link, 3X Mode (Multicarrier)

In this mode the signal consists of three single carriers corresponding to the signal of the 1X mode. The defined carrier spacing is 1.25 MHz and the CDMA2000 1X filter described in [2], section 3.1.3.1.14.2.1, is used.

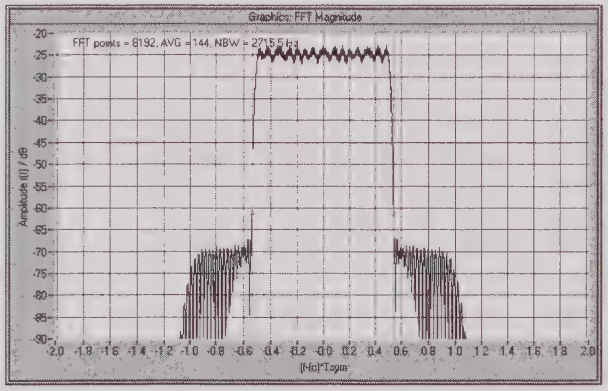


Fig. 12-39 Spectrum of magnitude of CDMA2000 3X signal (multicarrier, spacing 1.25 MHz)

The three single carriers are shown in the display as one wide carrier. The single carriers become visible when the carrier spacing is increased to eg to 2 MHz.

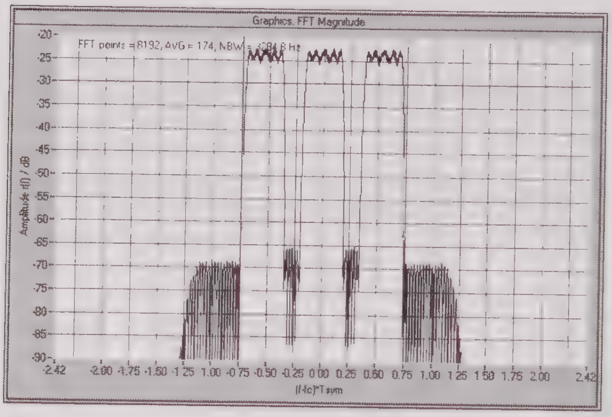


Fig. 12-40 Spectrum of a CDMA2000 3X signal (multicarrier, spacing 2.0 MHz)

Note: *In the multicarrier mode a resampler is used for signal calculation. The characteristics of the resampler (eg lowpass characteristic) modify the spectrum in the stopband.*

12.3.2 Effects on Crest Factor

The crest factor of the signal is mainly influenced by the following parameters:

- Link direction
  By modifying the Q component of the long code in the uplink (with QPSK modulation only, see section 12.3.1.1.2) every second zero crossing can be avoided. In contrast to the downlink, the crest factor is reduced by approx. 1.7 dB. The effect decreases as the number of channels increases.
- Sequence length
  Longer sequences cause higher peak values and hence larger crest factors since the probability of even higher peak values increases.
- Number of channels
  More channels yield larger crest factors
- Selection of spreading codes
  Neighbouring spreading code numbers usually result in smaller crest factors than numbers distributed over the full range of available values.

  Example: 8 channels with spreading code numbers 0 to 7: 9.44 dB
  16 channels with spreading code numbers 0, 8 16 to 96, 112: 12.33 dB
- Value of clipping level (see section 8.2.2.8)
  By limiting the signal, the crest factor can be reduced to almost any low value.

13 TD-SCDMA

WinIQSIM can generate TD-SCDMA signals. Section 13.1 gives an overview of this mobile radio transmission method. Section 13.2 describes the associated control functions. Section 13.3 provides in-depth information about the generation of TD-SCDMA signals.

13.1 Mobile Radio Transmission Method TD-SCDMA

TD-SCDMA (time-division synchronous CDMA) designates a mobile radio transmission method developed by the China Wireless Telecommunication Standard group (CWTS, http://www.cwts.org). This standard is similar to the 3GPP TDD proposition, but with greater emphasis placed on GSM compatibility and with a chip rate limited to 1.28 Mcps.

References:

[1] SIEMENS FRS TD-SCDMA Physical Layer 1.0 (11.03.2000)
[2] SIEMENS Additional Information to FRS (01.02.2001)

WinIQSIM simulates TD-SCDMA at the physical channel layer. The explanations given in the following are therefore restricted to this layer.

Table 13-1 TD-SCDMA parameters

Chip rate	1.28 Mcps
Carrier spacing	1.6 MHz
Data modulation	QPSK
Filter	Root-raised cosine (0.22)
Channel types	Downlink: • Primary Common Control Physical Channel (P-CCPCH) • Secondary Common Control Physical Channel (S-CCPCH) • Physical Forward Access Channel (F-FACH) • Downlink Pilot Time Slot (DwPTS) • Dedicated Physical Channel (DPCH) Uplink: • Physical Random Access Channel (P-RACH) • Uplink Pilot Time Slot (UpPTS) • Dedicated Physical Channel (DPCH)
Data rates	17.6 kbps, 35.2 kbps, 70.4 kbps to 281.6 kbps depending on channel type
Number of channels	4 cells, each containing max. 7 active slots. Each slot with up to 16 DPCHs and 5 special channels.
Frame structure	Frame: 5 ms with 7 (traffic) time slots Time slot (traffic): 675 µs Time slot (DwPTS): 75 µs Time slot (UpPTS): 125 µs The number of symbols transmitted in a slot depends on the symbol rate.
Scrambling code	128 different codes with length of 16 chips
SYNC codes	32 different codes with length of 64 chips
SYNC1 codes	256 different codes with length of 128 chips
Basic midamble codes	128 different codes with length of 128 chips
Spreading code	"Orthogonal Variable Spreading Factor Code (OVSF)"; spreading factors 1, 2, 4, 8, 16

TD-CDMA is a mobile radio standard in which available bandwidth is divided among subscribers according to frequency (FDMA), time (TDMA) and code (CDMA). The same frequency is used for both directions of transmission (TDD). Each resource (i.e. a combination of frequency, code and time slot) can be used simultaneously by several base or mobile stations provided the scrambling codes differ. A cell is understood to be a base station and all mobile stations communicating with this base station. WinIQSIM simulates a maximum of four cells at the same frequency.

Note: *To simulate more than four cells at the same frequency or cells at several frequencies, use the Multi Carrier Mixed Signal system (see section 13.3.2.2).*

13.1.1 TD-SCDMA Signal Structure (Frames and Time Slots)

The TD-SCDMA signal is organized in frames of 5 ms length. Each frame comprises 7 traffic time slots (Ts0 to Ts6, each 0.675 ms) and two special time slots (DwPTS and UpPTS) for synchronization.

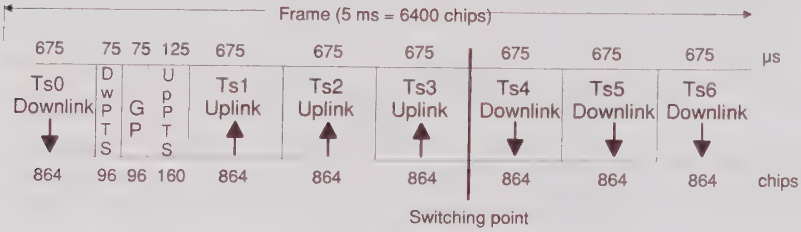

Frame (5 ms = 6400 chips)
675 75 75 125 675 675 675 675 675 675 µs
Ts0 Downlink
DwPTS
GP
UpPTS
Ts1 Uplink
Ts2 Uplink
Ts3 Uplink
Ts4 Downlink
Ts5 Downlink
Ts6 Downlink
864 96 96 160 864 864 864 864 864 864 chips
Switching point

Fig. 13-1 Structure of TD-SCDMA frame

Ts0 is always allocated to the downlink, Ts1 to the uplink. The other time slots are divided between the two directions of transmission, the switching point being variable.

13.1.2 DwPTS and UpPTS

In the downlink pilot time slot (DwPTS), the base station sends one of 32 possible 64-chip SYNC codes. The SYNC code allows the mobile station to synchronize to the base station. At the same time, the SYNC code defines the value range for the scrambling code and the basic midamble code.

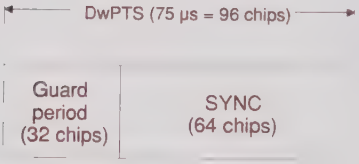


Fig. 13-2 Structure of DwPTS

The real-valued SYNC sequence is converted into a complex-valued SYNC sequence by a rotating-vector operation.
This SYNC sequence is divided up into four symbols with 16 chips each. The symbols are phase-modulated (possible phases are 45°, 135°, 225° and 315°) in order to signal the frame number of the interleaver.
In the supplied software, all symbols are modulated with 45°.

The uplink pilot time slot (UpPTS) is sent by the mobile station to initiate a call with the base station (before a P-RACH is sent, for example). The transmitted SYNC1 code is randomly selected from eight possible codes. If the base station does not respond to the UpPTS, the UpPTS is repeated in the next frame.

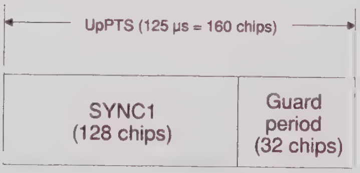


Fig. 13-3 Structure of UpPTS

The UpPTS is a complex-valued signal resulting from the real SYNC1 sequence by a rotating-vector operation.

13.1.3 Structure of Traffic Burst

In time slots Ts0 to Ts6, bursts can be sent by the base station or the mobile station, i.e. in both directions of transmission. The burst structure is identical for both directions. There are two types of burst, however, which are described in the following.

13.1.3.1 Burst Without Layer 1 Control Information

This type of burst can be used for all physical channels. It comprises two data fields, a midamble and a guard period.

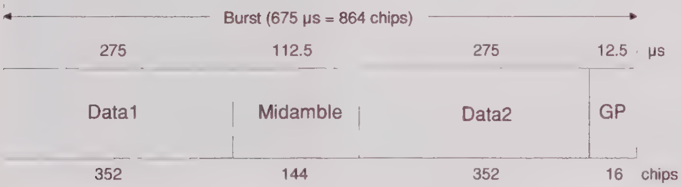


Fig. 13-4 Traffic burst without layer 1 control information

The useful data are

- alternately fed to the I and the Q path (QPSK data modulation),
- mapped from the 0/1 plane into the –1/+1 plane,
- spread with the complex spreading code (spreading factor SF = 1, 2, 4, 8 or 16),
- scrambled with the real-valued scrambling code,
- weighted with the channel power and
- filtered (root-raised cosine 0.22)

Since each user sends only one burst per frame, the following gross data rate is obtained:

$$Gross\_Data\_Rate = \frac{704*2}{SF*5ms} = 281600/SF\ \text{kbit/s}$$

The midamble is obtained from the basic midamble by periodic repetition and shifting. For some channels, the midamble shift can be set in steps of 8 chips. The basic midamble is 128 chips long. Each scrambling code (setting parameter at cell level) is assigned a basic midamble code.
The midamble is neither spread nor scrambled.

No signal is transmitted during the guard period. This avoids crosstalk of the burst into the next time slot at the receiver end.

13.1.3.2 Burst With Layer 1 Control Information

This type of burst can be used only with DPCHs (dedicated physical channels). It differs from the "normal" burst (see section 13.1.3.1) only in that the data fields are shortened ahead of and after the midamble to enable the transmission of layer 1 control information.

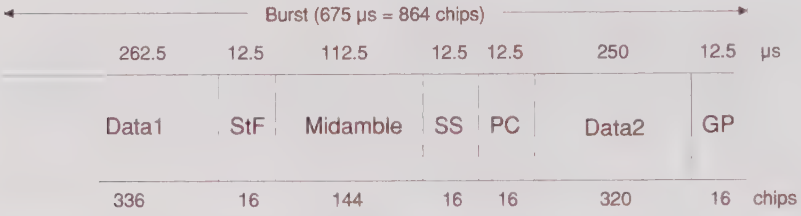


Fig. 13-5 Traffic burst with layer 1 control information

The stealing flag (StF) consists of 2 bits. Same as with GSM, these bits indicate whether all bits with an even index (first bit = '1') or an odd index (second bit = '1') were replaced by signalling bits.

The synchronization shift (SS) field likewise consists of 2 bits which are used to inform the other station of a shift of the burst time ("'00" means that the sync shift is increased, "11" that it is decreased). The two bits are transmitted in *M* consecutive frames.

The shift value is a multiple *k* of $T_{chip}/8$. *M* and *k* are transmitted by signalling. The value for *M* can be selected in WinIQSIM.

Analogously to the SS field, the power control (PC) field is used to initiate an increase or decrease of transmit power.

If the spreading factor SF is lower than 16, the control symbols are transmitted 16/SF times. Control symbols are treated like data symbols, i.e. they are spread and scrambled.

13.2 Generation of TD-SCDMA Signals with WinIQSIM

To generate a TD-SCDMA signal, the TD-SCDMA system must be selected.

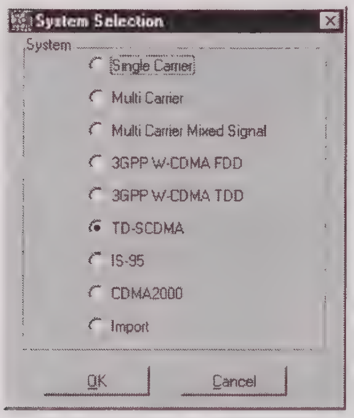


Fig. 13-6 Selection of TD-SCDMA system

The System Selection menu is accessible via the File/New... menu or via "System!". The differences between the two methods are described in sections 5.22.1 and 5.23.

The TD-SCDMA block diagram is based on that of the Single Carrier system. The Data Source block has been extended and the Modulation block replaced by the TD-SCDMA Configuration block.

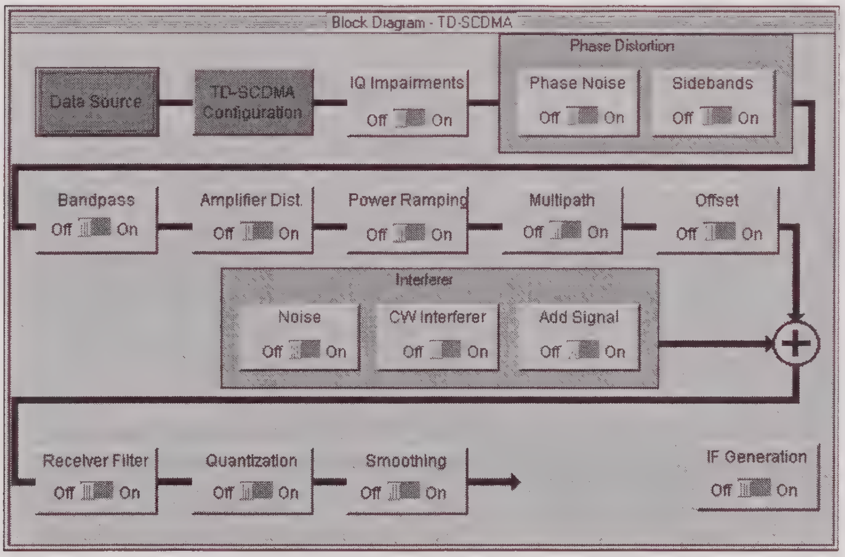


Fig. 13-7 Block diagram of TD-SCDMA system

The Data Source block corresponds to that of the Multi Carrier system. For information please refer to section 7.2.

13.2.1 Status Line

The main parameters of the TD-SCDMA transmission system are displayed in the status line, below the toolbar of the main panel. So, the set parameters can be seen at a glance.

The status line contains icons for the different parameters. Below the icons the current parameter values are indicated. The following illustration shows the status line of the TD-SCDMA system with parameter values assigned to the icons.

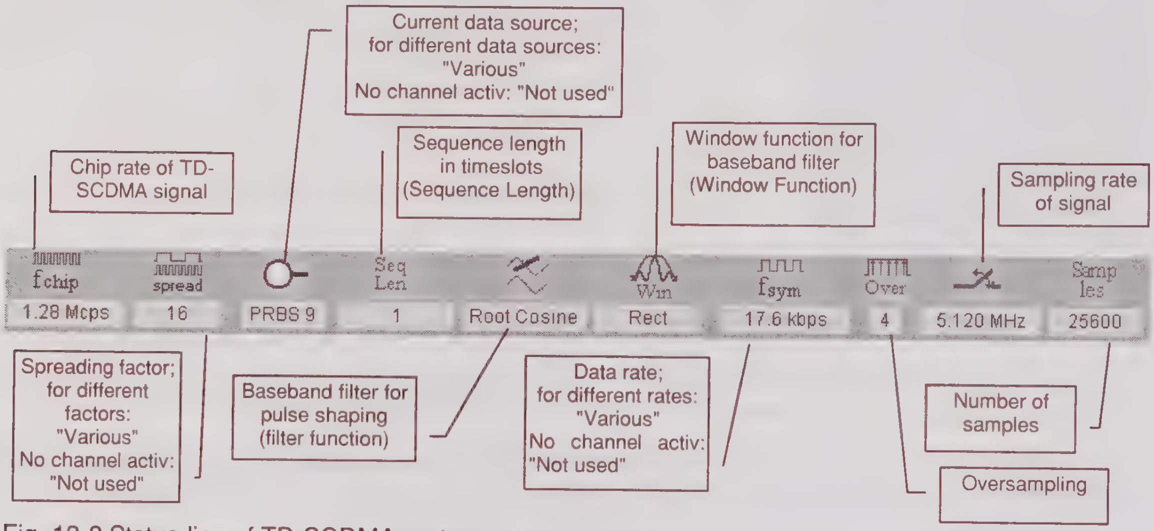
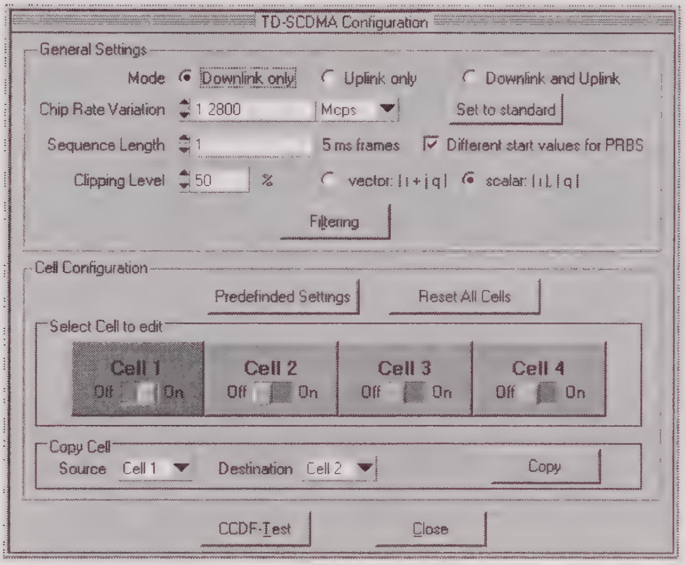

Current data source; for different data sources: "Various" No channel activ: "Not used"
Chip rate of TD-SCDMA signal
Sequence length in timeslots (Sequence Length)
Window function for baseband filter (Window Function)
Sampling rate of signal
fchip
spread
Seq Len
Win
fsym
Over
Samples
1.28 Mcps
16
PRBS 9
1
Root Cosine
Rect
17.6 kbps
4
5.120 MHz
25600
Spreading factor; for different factors: "Various" No channel activ: "Not used"
Baseband filter for pulse shaping (filter function)
Data rate; for different rates: "Various" No channel activ: "Not used"
Number of samples
Oversampling

Fig. 13-8 Status line of TD-SCDMA system

13.2.2 TD-SCDMA Configuration Panel

All parameters necessary for the definition of a TD-SCDMA signal (except for data sources and impairments) can be accessed via the TD-SCDMA Configuration panel.


TD-SCDMA Configuration

General Settings

Mode ● Downlink only ○ Uplink only ○ Downlink and Uplink

Chip Rate Variation 1.2800 Mcps

Sequence Length 1 5 ms frames ☑ Different start values for PRBS

Clipping Level 50 % ○ vector: | i + j q | ● scalar: | i |, | q |

Cell Configuration

Select Cell to edit

Copy Cell

Source Cell 1 Destination Cell 2

Fig. 13-9 TD-SCDMA Configuration panel

13.2.2.1 General Settings

The following parameters are defined in the General Settings panel:

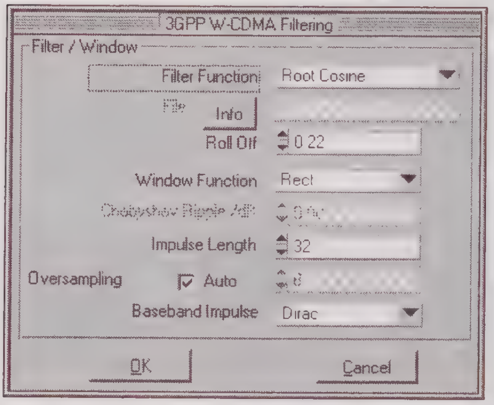
- **Mode**
  Here it is defined whether only the base station (downlink only) or only the mobile stations (uplink only) or both types of station (downlink and uplink) should be active in a cell.
- **Chip Rate Variation**
  This parameter allows changing the output chip rate (i.e. the rate of spread symbols used for signal output by AMIQ, for example) as against the standard chip rate of 1.28 Mcps. The standard chip rate of 1.28 Mcps can be restored any time by means of the **Set to standard** button.
- **Sequence Length**
  The length of the signal to be generated can be set in 5 ms frames.
  The number of chips per frame is 6400.
- **Different start values for PRBS**
  If this button is active, the PRBS generators of the individual channels are initialised with different start values. As result, all channels are calculated with independent source data.

  Note: *This button is effective only for the data source designated "Data Source PRBS". If, for example, "Data Source 0" with PRBS16 is used, the button is ignored, i.e. all channels using Data Source 0 are calculated with identical PRBS bit sequences.*
- **Clipping Level**
  A clipping value can be set as a percentage of the highest peak. The range is 1 to 100 %.
  A value of 100 % means that the signal is not clipped. Clipping reduces the crest factor.
  Clipping can be effected based on two different parameters:
  vector | i+jq | : The instantaneous amplitudes | i+jq | are used as peak value.

scalar | i |,| q | : The absolute maximum of all I and Q values is used as peak value.
For more detailed information on this parameter see section 13.2.2.7.

13.2.2.2 Filtering

The raw chips generated are subjected to baseband filtering which is implemented same as for the Single Carrier system.



3GPP W-CDMA Filtering

Filter / Window

Filter Function: Root Cosine

Roll Off: 0.22

Window Function: Rect

Impulse Length: 32

Oversampling: ☑ Auto

Baseband Impulse: Dirac

Fig. 13-10 TD-SCDMA filtering

For a description of the individual parameters, therefore, refer to section 5.8, "Modulation Settings Panel").

For the filtering of TD-SCDMA signals, the parameter settings shown in Fig. 13-10 are recommended.

13.2.2.3 Cell Configuration

The TD-SCDMA system can simulate signals for up to four cells.

13.2.2.3.1 Common Setting of All Cells

The Cell Configuration panel (see Fig. 13-9) comprises two buttons:

- **Predefined Settings**
  If this button is clicked, a panel opens where you can define parameterizable predefined settings. Complex signal scenarios can thus be generated very easily. For details please refer to section 13.2.2.4.
- **Reset All Cells**
  All cells are reset to predefined settings, which are shown in the table below.

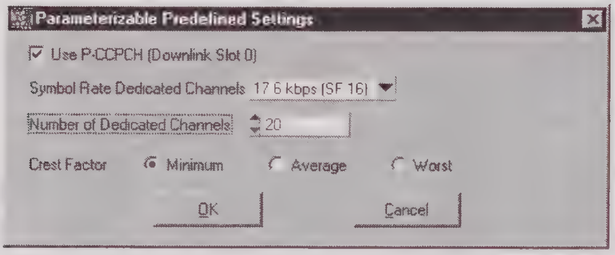
Table 13-2 Reset values for cells

Common parameters of cells	Reset value
State	Off
Scrambling code	0
Scrambling code off	If button is deactivated, scrambling code is active
SYNC code	0
Switching point	3
Use L1 control fields in DPCH	Off
DwPTS power	0.0 dB
Parameters of slots	**Reset value**
State	Off
Slot mode	Downlink dedicated or uplink dedicated
TPC pattern read out mode	Continuous
Sync shift repetition M	1
Stealing flag	0
Parameters of channels	**Reset value**
Symbol rate	17.6 kbps (SF16)
Spreading code	0
Midamble shift	0
Power	0 dB
Data source	PRBS for all channels
Sync shift	
TPC pattern	0 for all channels
State	Off for all channels

- **Select Cell to Edit**
  In this panel, the cells are shown as blocks. They can be switched on or off. Active cells are highlighted green, passive cells are shown grey. So you can see at a glance which cells are currently active. If you wish to edit the parameters of a cell, simply click the corresponding block. A window for configuring the cell parameters opens (see section 13.2.2.5).
- **Copy Cell**
  This panel allows you to copy the configuration of a cell to another cell. In the Source field select the cell to be copied, in the Destination field the cell to be overwritten. Start copying by clicking the Copy button. You can thus easily create a scenario of several cells after having configured one cell. After copying, only the cell-specific parameters such as scrambling code have to be changed to simulate different cells.
- **CCDF Test**
  This button opens a window in which a complementary cumulative distribution function is displayed. For details see section 8.2.2.7.
- **Close**
  If this button is selected, the TD-SCDMA Configuration panel is closed.

13.2.2.4 Parameterizable Predefined Settings

This panel is used for defining parameterizable predefined settings. Complex signal scenarios can be generated very easily in this way.



☑ Use P-CCPCH (Downlink Slot 0)

Symbol Rate Dedicated Channels: 17.6 kbps (SF 16)

Number of Dedicated Channels: 20

Crest Factor: ● Minimum ○ Average ○ Worst

Fig. 13-11 Parameterizable Predefined Settings panel

The following rules apply:

- Channels are assigned only to one cell.
- The switching point is always set to 3.
- Downlink and/or uplink channels are set depending on the selected mode.
- In slot 0, a P-CCPCH can optionally be activated; no DPCHs will be activated in this slot.

With the option **Use P-CCPCH (Downlink Slot 0)** you can choose whether the signal is to contain a primary common control physical channel.

You can select the number of DPCH channels to be used in the scenario plus their symbol rate. In the Downlink and Uplink mode, the defined number of channels is simulated both in the downlink and in the uplink.

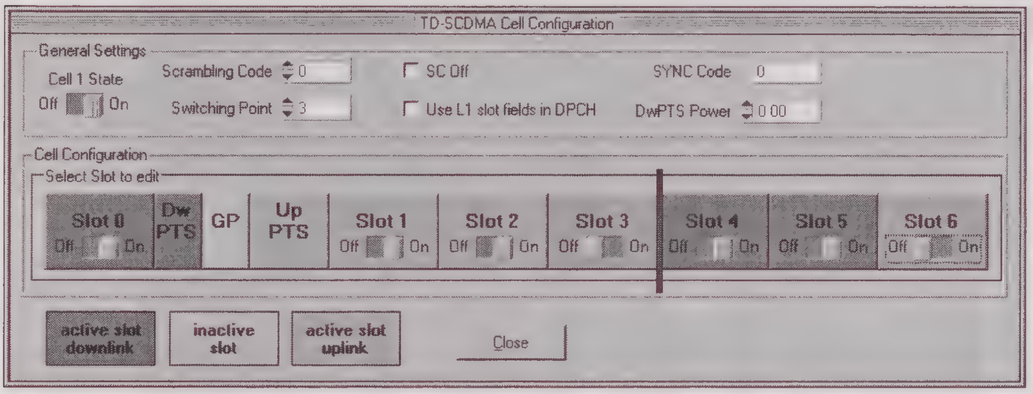
Since a maximum of three slots can be occupied in each link direction, the number of DPCHs is limited to 3*SF, i.e. to max. 48.

In the **Crest Factor** section, you can configure the signal scenario for minimum, average or worst crest factor. WinIQSIM automatically selects the required channel parameters by varying the distribution of channels across the slots and the spreading code of the channels.

On clicking the *OK* button, the parameters and the channel tables of the cells in question are automatically configured in accordance with the parameters entered.

13.2.2.5 TD-SCDMA Cell Configuration Panel

If you click one of the cell blocks in the TD-SCDMA Configuration panel, the TD-SCDMA Cell Configuration panel is opened. The TD-SCDMA Configuration panel is displayed at the same time but is dimmed since the two windows are interrelated in many ways. The TD-SCDMA Configuration parameters can be read but not changed. When the TD-SCDMA Cell Configuration panel is closed (Close), the TD-SCDMA Configuration panel is enabled again.


TD-SCDMA Cell Configuration

General Settings

Cell 1 State Off / On

Scrambling Code 0

Switching Point 3

☐ SC Off

☐ Use L1 slot fields in DPCH

SYNC Code 0

DwPTS Power 0.00

Cell Configuration

Select Slot to edit

Fig. 13-12 TD-SCDMA Cell Configuration panel

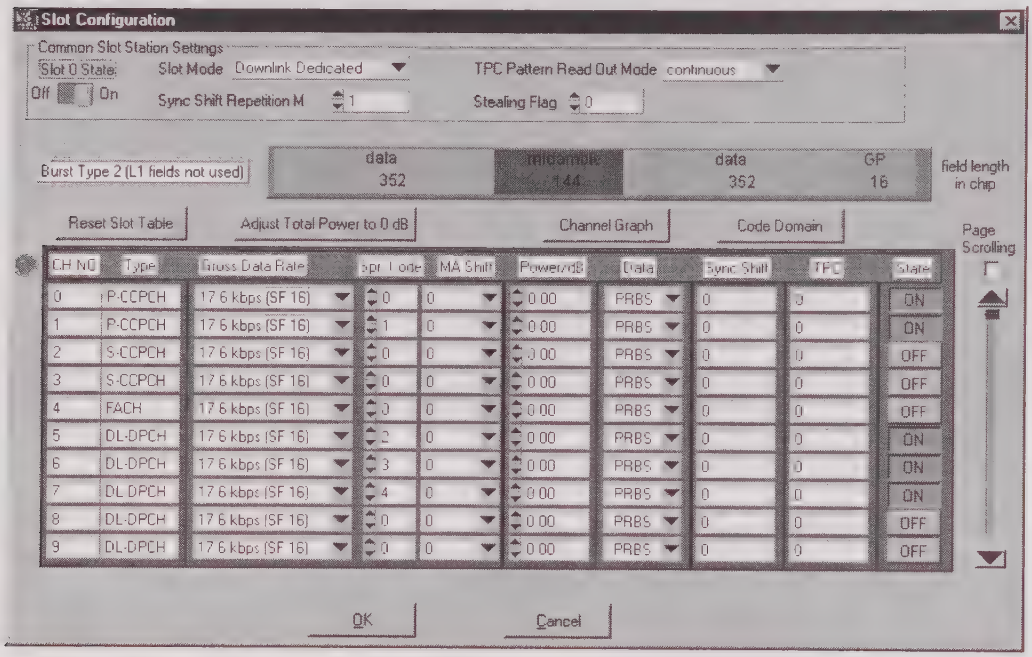
13.2.2.5.1 General Settings

In this section, parameters valid for the complete cell can be set.

- **Cell State**
  The complete cell can be switched on or off.
- **Scrambling Code**
  The scrambling code is used for transmitter-dependent scrambling of the chip sequence.
  The range of the scrambling code is 0 to 127.
- **SC Off**
  If this button is active, the scrambling code is deactivated for test purposes.
- **SYNC Code**
  The SYNC code is automatically set so that it matches the scrambling code. The SYNC code is transmitted in the DwPTS to synchronize the mobile station to the base station.
- **Switching Point**
  The switching point between the uplink slots and the downlink slots in the frame can be selected between 1 and 6.
- **Use L1 slot fields in DPCH**
  If this button is active, layer 1 control information (stealing flag, synchronization shift and power control) is included in the burst (see section 13.1.3.2).
- **DwPTS Power**
  The power of the downlink pilot time slot can be set between –60 dB and 0 dB.
- **Select Slot to Edit**
  Here the slots are represented as blocks. They can be switched on or off (only the traffic slots, which are provided with a switch). Active slots are highlighted green (downlink) or cyan (uplink), inactive slots are shown grey. So you can see at a glance which slots are currently active and whether they are downlink or uplink slots. If you wish to edit the parameters of a slot, simply click the corresponding block. The slot configuring panel opens.
- **Close**
  On clicking this button, the TD-SCDMA Configuration panel is closed.

13.2.2.6 Slot Configuration Panel

If you click one of the slot blocks in the TD-SCDMA Cell Configuration panel, the Slot Configuration panel opens. The TD-SCDMA Cell Configuration panel is displayed in the background but is not accessible since the two windows are interrelated in many ways. When the Slot Configuration panel is closed (OK or Cancel), the TD-SCDMA Cell Configuration panel is enabled again.



Slot 0 State: Off ☐ On
Slot Mode Downlink Dedicated
TPC Pattern Read Out Mode continuous
Sync Shift Repetition M 1
Stealing Flag 0

CH NO	Type	Gross Data Rate	Spr Code	MA Shift	Power/dB	Data	Sync Shift	TPC	State
0	P-CCPCH	17.6 kbps (SF 16)	0	0	0.00	PRBS	0	0	ON
1	P-CCPCH	17.6 kbps (SF 16)	1	0	0.00	PRBS	0	0	ON
2	S-CCPCH	17.6 kbps (SF 16)	0	0	0.00	PRBS	0	0	OFF
3	S-CCPCH	17.6 kbps (SF 16)	0	0	0.00	PRBS	0	0	OFF
4	FACH	17.6 kbps (SF 16)	0	0	0.00	PRBS	0	0	OFF
5	DL-DPCH	17.6 kbps (SF 16)	2	0	0.00	PRBS	0	0	ON
6	DL-DPCH	17.6 kbps (SF 16)	3	0	0.00	PRBS	0	0	ON
7	DL-DPCH	17.6 kbps (SF 16)	4	0	0.00	PRBS	0	0	ON
8	DL-DPCH	17.6 kbps (SF 16)	0	0	0.00	PRBS	0	0	OFF
9	DL-DPCH	17.6 kbps (SF 16)	0	0	0.00	PRBS	0	0	OFF

Fig. 13-13 Slot Configuration panel

- **Slot State**
  The complete slot can be switched on or off.
- **Slot Mode**
  If the slot is allocated to the downlink, the mode is fixed at "Downlink Dedicated".
  In the uplink, the slot can be used for simulation either in the dedicated mode (call established) or in the PRACH mode. In the dedicated mode, several mobile stations can be simulated, in the PRACH mode only one.
- **TPC Pattern Read Out Mode**
  The TPC bits are used to signal to the other station that the transmit power is increased or reduced. The TPC field can be defined independently for each channel of the slot in the channel table of this panel. The TPC Pattern Read Out Mode parameter defines how the bit pattern is to be used.
  The following modes are available:
  - **Continuous**
    From the bit pattern (max. 16 bits) for the transmit power control field of the slots, 2 bits are taken for each slot and introduced in the bit stream several times (depending on the symbol rate).
    The specified bit pattern is used cyclically.
  - **Single + All 0**
    From the bit pattern (max. 16 bits) for the transmit power control field of the slots, 2 bits are taken for each slot and introduced in the bit stream several times (depending on the symbol rate).
    The specified bit pattern is used once, then the TPC sequence is continued with "0" bits.

- **Single + All 1**
  From the bit pattern (max. 16 bits) for the transmit power control field of the slots, 2 bits are taken for each slot and introduced in the bit stream several times (depending on the symbol rate).
  The specified bit pattern is used once, then the TPC sequence is continued with "1" bits.
- **Single + alt. 01**
  From the bit pattern (max. 16 bits) for the transmit power control field of the slots, 2 bits are taken for each slot and introduced in the bit stream several times (depending on the symbol rate).
  The specified bit pattern is used once, then the TPC sequence is continued with alternating "0" and "1" bits (used multiply depending on the symbol rate, e.g. 00001111).
- **Single + alt. 10**
  From the bit pattern (max. 16 bits) for the transmit power control field of the slots, 2 bits are taken for each slot and introduced in the bit stream several times (depending on the symbol rate).
  The specified bit pattern is used once, then the TPC sequence is continued with alternating "1" and "0" bits (used multiply depending on the symbol rate, e.g. 11110000).

The different modes can be used, for example, to set a mobile to a defined output power (e.g. with pattern 11111) and maintain it at this power (with **Single + alt. 01** or **Single + alt. 10**). This allows power measurements on the mobile (with constant power in this case).

All further settings depend on the mode.

13.2.2.6.1 Settings of Slot Configuration Panel in Dedicated Mode

In the downlink and in the uplink (mode = Uplink Dedicated), several channels can be simulated simultaneously. In the downlink, all channels originate from a base station and are directed either to all mobile stations (e.g. P-CCPCH) or to selected mobile stations (DPCH). In the uplink, DPCHs are simulated which transmit to the only base station of the cell. Channels originating from the same mobile station or directed to the same mobile station are characterized by an identical midamble shift.

- **Sync Shift Repetition M**
  The sync shift bits are coded in M consecutive frames. The maximum value is 500 (see also section 13.1.3.2).

- **Stealing Flag**
  The stealing flag consists of 2 bits and can assume values between 0 and 3.

  Note: *The stealing flag is coded in the signal without any modification to the contents of the data fields.*

  Below this, the current slot structure is displayed. The structure depends on the status of the "Use L1 slot fields in DPCH" button (see section 13.2.2.5.1).

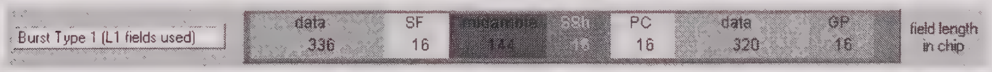


Fig. 13-14 Slot structure with active L1 fields

13.2.2.6.2 Channel Table of a Slot

The major part of the Slot Configuration panel is taken up by the scrollable channel table. The table elements can be edited directly. The parameters shown in the table columns are explained below.

- **CH NO**
  In the first column, consecutive channel numbers starting with 0 are displayed. A WinIQSIM base station comprises special channels, such as P-CCPCH, and 16 DPCHs. All channels can be configured separately. Channels not configurable for the slot are dimmed.
- **Type**
  The channel type is displayed. The first code channels of the table are reserved for special channels P-CCPCH, S-CCPCH and FACH. The remaining code channels are DPCHs. The channel type is displayed for information only; it cannot be edited.
- **Gross Data Rate**
  Here you can allocate a data rate or spreading factor to a code channel. The range of the symbol rate varies depending on the channel type. The P-CCPCH is allocated a fixed data rate of 17.6 ksps (SF16), for example. DPCHs, on the other hand, can be assigned any data rate between 17.6 kbps (SF16) and 281.6 kbps (SF1).
- **Spr. Code**
  The spreading code (for the code channels) can be selected. The range depends on the channel data rate.
  The maximum range is 0 to SF –1.
- **Midamble Shift**
  The midamble shift can be defined between 0 and 120 in steps of 8. Channels belonging to the same mobile station are characterized by the same midamble shift.
- **Power/dB**
  The power of the code channels can be set between –60 dB and 0 dB.
- **Data**
  One of four data sources (Data 0, Data 1, Data 2 or PRBS) can be selected. For a description of the data sources see section 7.2. The Data field is not accessible for channel types that contain no data fields (e.g. P-SCH).
- **Sync Shift**
  A pattern of max. 16 bits can be entered from which the bits for the sync shift field (2 bits per slot) are taken. The pattern is read cyclically.
- **TPC**
  In this field, you can enter a pattern of max. 16 bits for the transmit power control field of the slots. 2 bits per slot are taken from this pattern and multiply introduced into the bit stream (depending on the data rate). The specified bit pattern is used in accordance with the selected TPC Pattern Read Out Mode (see section 13.2.2.5.1).
- **State**
  With this button you can select whether or not a given code channel should be included in your signal scenario. The State buttons of the active channels are highlighted green, so you can identify the active channels at a glance.

The scrollbar on the right allows scrolling up and down the table. The following modes are supported:

Table 13-3 Scrollbar modes

Function	Required actions
Scrolling the table line by line	- Switch off Page Scrolling ☐ Page Scrolling - Click the large arrows ▲, ▼ or – Click the black box ■ -> scrollbar is activated – Press <Up> / <Down> cursor keys
Scrolling the table page by page	- Switch on Page Scrolling ☑ Page Scrolling - Click the large arrows ▲, ▼
Jumping to any position in the table	- Click black box ■ (keep mouse key pressed) – Move to desired position – Release lefthand mouse key

13.2.2.6.3 Reset Slot Table

With the Reset Slot Table button, you can reset the channel table parameters of the slot to defined settings. This does not affect the parameters of the Common Slot Settings panel. The reset values are shown in the following table.

Table 13-4 Reset values of slot channel table

Code channel parameter	Reset value for all channels
Gross data rate	17.6 kbps (SF 16)
Spreading code	0
Midamble shift	0
Power	0 dB
Data source	PRBS
Sync shift	0
TPC pattern	0
State	Off

13.2.2.6.4 Adjust Total Power to 0 dB

The power of the individual code channels is set so that the total power of all active channels is 0 dB. The set power differences between the channels remain the same but the total power is normalized to 0 dB. This mode can be used to send the individual code channels precisely with the power defined in WinIQSIM from Signal Generator SMIQ (with a set effective transmit power of 0 dB).

13.2.2.6.5 Channel Graph

This graph shows all active channels at a glance.

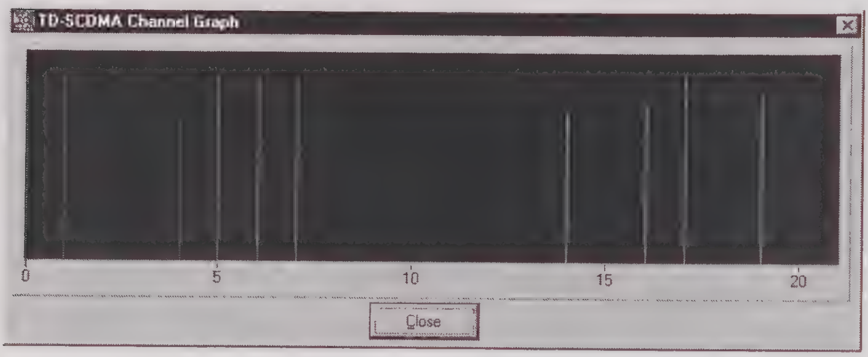


Fig. 13-15 Channel graph

The special channels (P-CCPCH, S-CCPCH and FACH) are shown by red lines, the DPCHs by green lines. The length of the lines indicates the channel power.

13.2.2.6.6 Code Domain

This graph shows all active channels in the code domain.

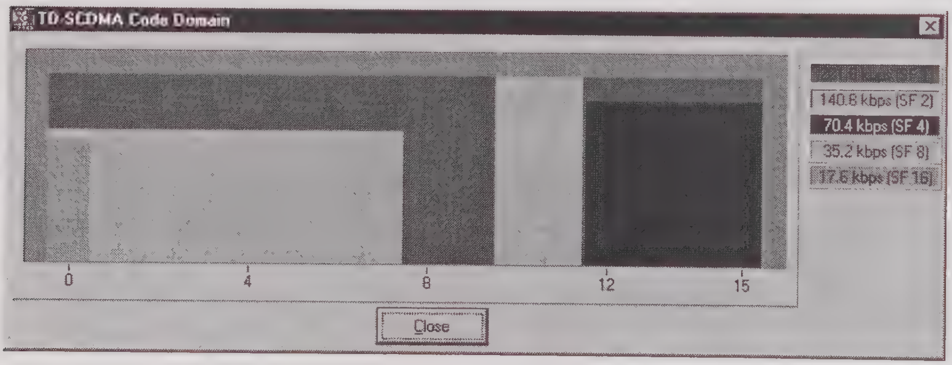


Fig. 13-16 Code domain display

This graph as well as the signalling and resolving of code domain conflicts are described in section 8.2.2.5.6.

13.2.2.7 Effect of Clipping Level on Signal

The envelope of a TD-SCDMA signal comprises three parts:

- active slots in the downlink (incl. DwPTS)
- active slots in the uplink (incl. UpPTS)
- inactive slots

WinIQSIM evaluates all three parts in average, peak and CCDF calculation. Depending on their position in the signal path, certain system components only "see" certain sections of the frame, so that different values are obtained for CCDF for example.

Example: *For the antenna at the receive end the complete signal is relevant, at the transmit end only the active slots in the direction of transmission.*

TD-SCDMA signals may have very large crest factors, in particular if a large number of channels and many inactive slots are involved. Large crest factors entail two basic problems:

1. Nonlinearity of the power amplifiers (compression) causes intermodulation, which expands the spectrum (spectral regrowth).
2. Since the D/A converters are driven oriented to the maximum value, average-value conversion takes place with relatively low resolution. The result is high quantization noise.

Each of these effects increases adjacent-channel power.

The simplest and most effective way of reducing the crest factor (often also referred to as peak-to-average ratio or PAR) is by changing the clipping level. The clipping level is a limit value expressed as a percentage of the highest peak value.
All instantaneous values exceeding the limit value are reduced to this value. Clipping is done prior to filtering so that it has no negative effect on the spectrum. EVM increases however.

Since clipping of the signal not only changes the peak but also the average values, its effect on the crest factor is not immediately predictable. The following table shows the effect of the clipping level on the crest factor for some typical scenarios.

Table 13-5 Change of crest factor through clipping

CLIPPING LEVEL	Crest factor for scenario			
	Downlink + Uplink : 48 DPCHs "minimum crest"	Downlink : 48 DPCHs "minimum crest"	Downlink + Uplink : 10 DPCHs "average crest"	Downlink : 10 DPCHs "average crest"
100 %	9.47 dB	11.47 dB	7.78 dB	9.71 dB
80 %	8.77 dB	10.75 dB	6.26 dB	8.33 dB
50 %	7.33 dB	9.42 dB	6.51 dB	8.64 dB
20 %	5.82 dB	8.10 dB	4.56 dB	6.95 dB
10 %	5.69 dB	8.11 dB	4.56 dB	6.95 dB
5 %	5.80 dB	8.26 dB	4.56 dB	6.95 dB

The scenarios were set with the "Para. Predef." function.

Other settings:

- Data rate 17.6 kbps (SF 16)
- Scalar clipping mode
- One P-CCPCH active
- Root cosine 0.22 filter

The figures below show the effects of clipping on the constellation for a 10-DPCH configuration.

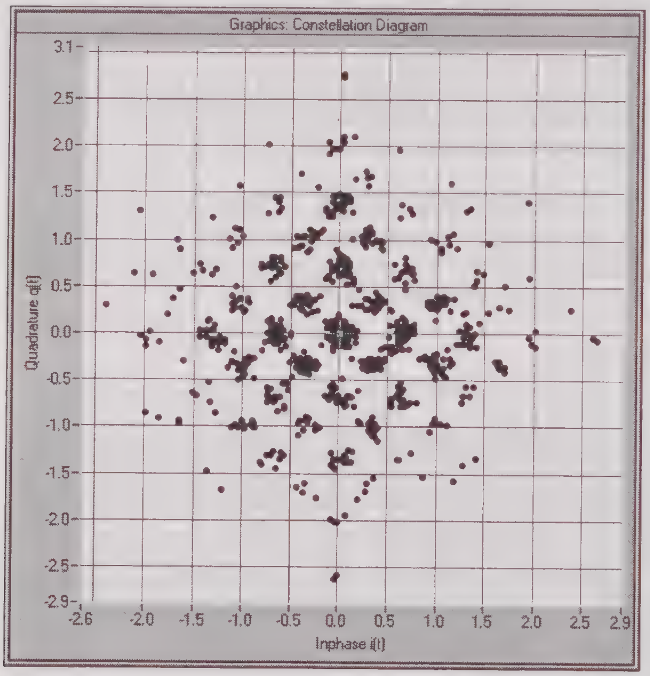


Fig. 13-17 Constellation for 100 % clipping level (no clipping)

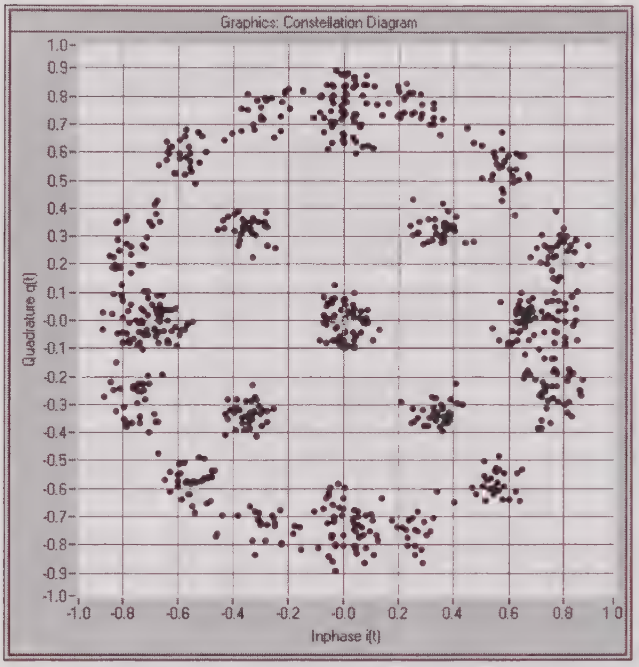


Fig. 13-18 Constellation for 30 % clipping level (vector clipping)

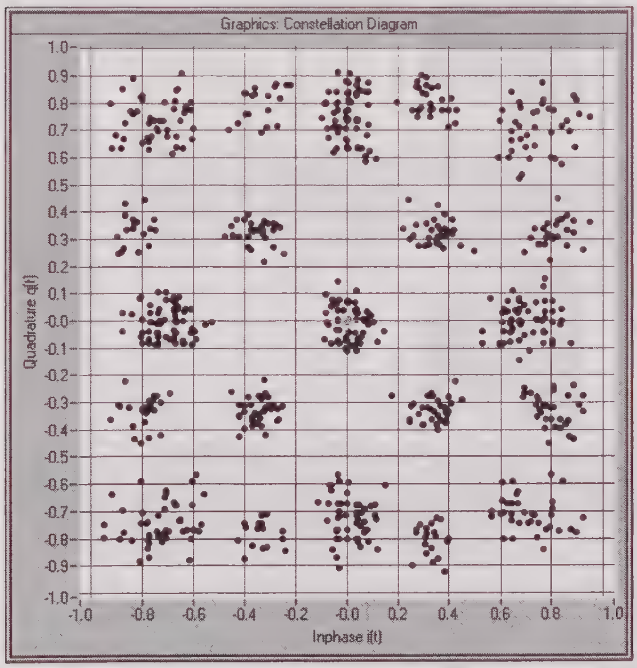


Fig. 13-19 Constellation for 30 % clipping level (scalar clipping)

13.3 Further Information for the Generation of TD-SCDMA Signals

13.3.1 TD-CDMA Signals Shown in Time-Domain and Constellation Display

In the following a signal with a P-CCPCH in slot 0 and a PRACH in slot 1 is to be generated. Other settings:

- Sequence length: 2 frames
- Filtering: root cosine (roll-off = 0.22), pulse length = 32, oversampling = 4
- Data source: PRBS9
- No superimposed impairments active
- UpPTS start frame: 1; UpPTS repetition: 1
- Channel powers: P-CCPCH: -3 dB, DwPTS: -1 dB, PRACH: -7 dB
- Spreading codes and midamble shifts: 0

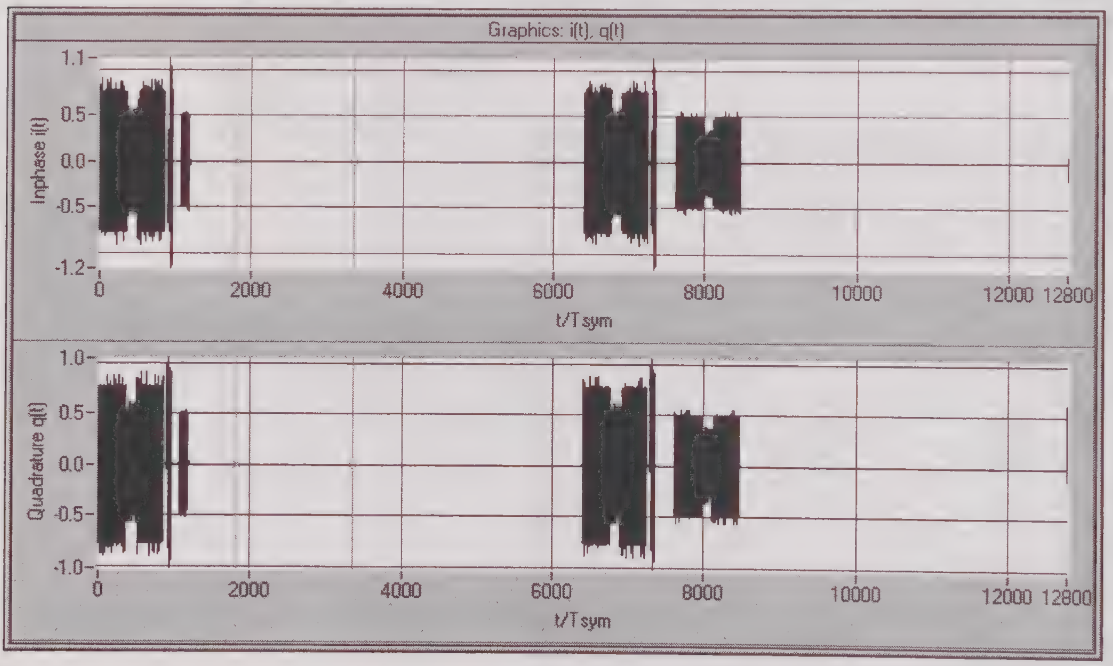


Fig. 13-20 Time-domain display of signal comprising a P-CCPCH and a PRACH

The above display shows two frames of 6400 chips each. In both frames, slot 0 (P-CCPCH, in first frame: chips 0 to 863) and the DwPTS (in first frame: chips 864 to 859) are active. Moreover, the UpPTS in the first frame (chips 1056 to 1215) and the PRACH in slot 1 of the second frame can be seen.

Below, the signal sections are shown in detail:

Note: *In the following, filtering is changed to "Rect" to provide a clearer display of powers and time characteristics.*

Slot 0 (P-CCPCH)

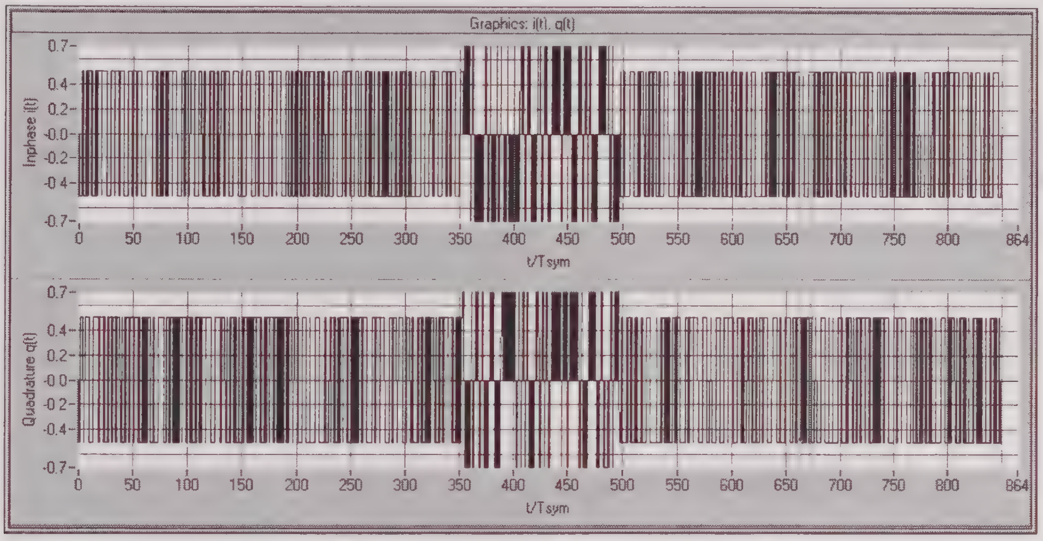


Fig. 13-21 Time-domain display of P-CCPCH signal with power –3 dB

The 3 subranges representing the data fields, the midamble and the guard period are clearly discernible. Below is the same signal shown as a constellation diagram:

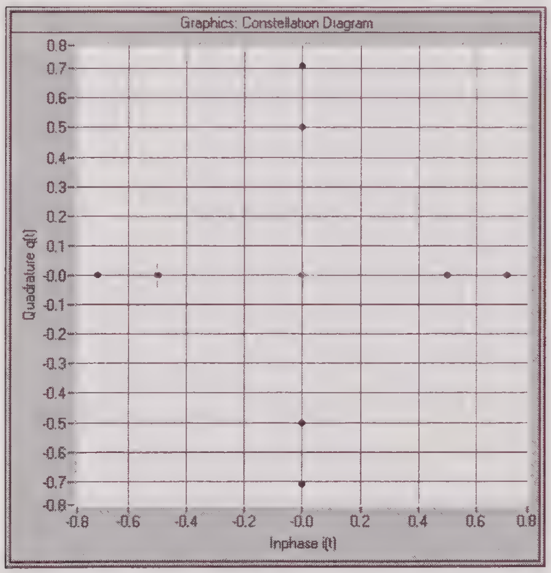


Fig. 13-22 Constellation diagram of P-CCPCH signal with power –3 dB

In this diagram, too, three subsections are discernible:

Data fields

Data bits $b_i \in \{0,1\}$ are alternately assigned to the I and the Q path and mapped into the I/Q plane according to the formula

consecutive binary bit pattern	complex symbol
${}^{(k,i)}_{1,n}$ ${}^{(k,i)}_{2,n}$	$\underline{d}_{n}^{(k,i)}$
00	+j
01	+1
10	-1
11	-j

Spreading is effected by multiplication by a complex value from the set { 1, j, -1, -j }, which corresponds to a shift of n*90° and has therefore no effect on the constellation. Scrambling (real-valued multiplication by 1 or –1) does not have any effect on the constellation either.
Taking into account a channel power of

$$-3 \text{ dB} = \frac{1}{\sqrt{2}},$$

the four points are obtained on the axes as shown in Fig. 13-22.

.

Midamble — *The midamble is obtained by multiplying a { -1, +1 } sequence by a rotating vector* $(j)^i$.As the power of the midamble is reduced by 3 dB as against the set channel power, four points are obtained on the axis with the amplitude 0.5.,

Guard period — *No signal is sent during the guard period (I=Q=0), which is reflected by the point positioned at the coordinate origin.*

DwPTS

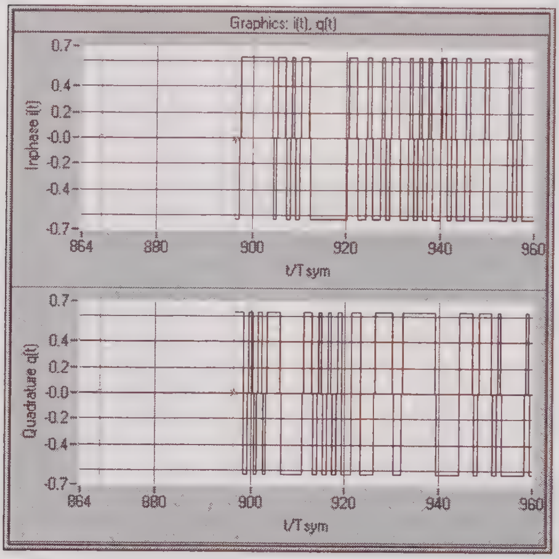


Fig. 13-23 Time-domain display of DwPTS signal with power -1 dB

The downlink pilot time slot consists of a guard period and a phase-modulated SYNC sequence. With power –1 dB, a QPSK constellation with amplitude 0.9 is obtained.

UpPTS

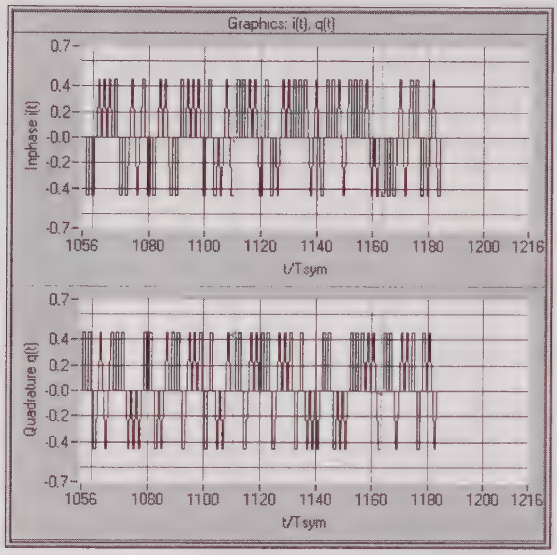


Fig. 13-24 Time-domain display of UpPTS signal with power -7 dB

The uplink pilot time slot consists of a complex-valued SYNC1 sequence, which is followed by a guard period.

PRACH
The PRACH burst in slot 1 of the second frame has the same structure as the P-CCPCH described in section 13.1.3.1.

13.3.2 Simulation of Complex Scenarios

The TD-SCDMA system has certain limitations to keep its operation as simple as possible:

- only one carrier frequency
- max. four cells
- no delays between the cells
- only one PRACH per slot and cell
- no mixed operation involving PRACH and dedicated mode in a slot of a cell

13.3.2.1 Generating Several Logical Cells from One Cell

To simulate several PRACH bursts in one slot, proceed as follows:

➢ Configure cell 1 as desired and activate the first PRACH.

➢ Copy cell 1 to cell 2 and modify the PRACH settings in cell 2.

➢ If necessary, repeat the above steps for cells 3 and 4.

Analogously, PRACH and dedicated mode can be combined in one slot.

13.3.2.2 Combination with Multi Carrier Mixed Signal

The Multi Carrier Mixed Signal system offers the possibility of versatile extensions. Several waveforms (up to 32) can be added. For a detailed description please refer to section 10.

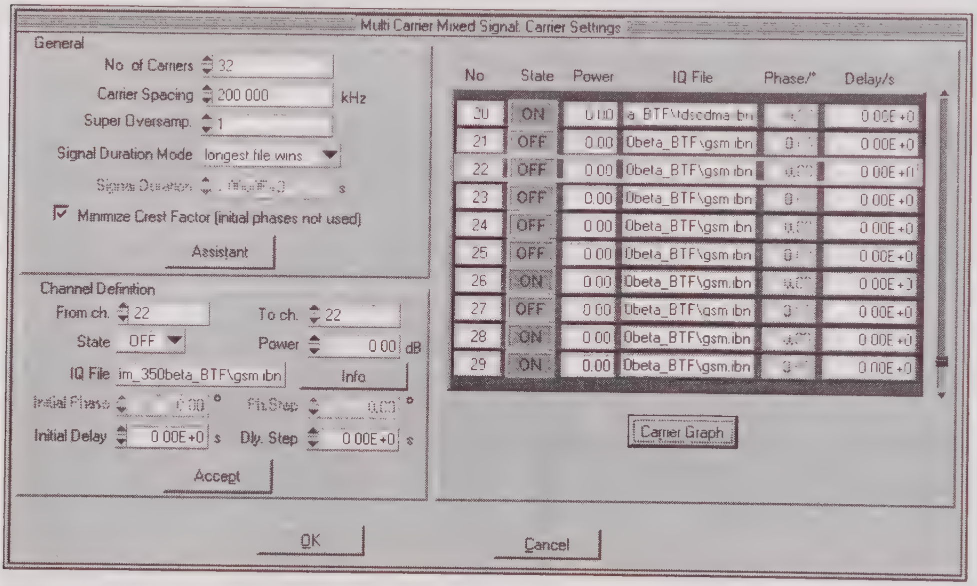
First save the waveforms in any desired system under "File/Save for Add/Multi Carrier Mixed Signal". Then go to the Multi Carrier Mixed Signal system, where you can add the saved waveforms (IBN format, i.e. full floating-point notation).

13.3.2.2.1 Simulation of Multi Carrier Scenarios

This is the main application of the Multi Carrier Mixed Signal system.

- ➢ Enter channel spacing of 1.6 MHz (or 0.2 MHz if you wish to combine TD-SCDMA with GSM).
- ➢ Assign waveforms to the channels as desired.

Example of mixed TD-SCDMA/GSM scenario:



General

No. of Carriers 32

Carrier Spacing 200 000 kHz

Super Oversamp. 1

Signal Duration Mode longest file wins

Signal Duration [illegible] s

☑ Minimize Crest Factor (initial phases not used)

Channel Definition

From ch. 22 To ch. 22

State OFF Power 0.00 dB

IQ File im_350beta_BTF\gsm.ibn

Initial Phase 0.00 ° Ph. Step 0.00 °

Initial Delay 0.00E+0 s Dly. Step 0.00E+0 s

No	State	Power	IQ File	Phase/°	Delay/s
20	ON	0.00	a_BTF\tdscdma.ibn	[illegible]	0.00E+0
21	OFF	0.00	0beta_BTF\gsm.ibn	[illegible]	0.00E+0
22	OFF	0.00	0beta_BTF\gsm.ibn	[illegible]	0.00E+0
23	OFF	0.00	0beta_BTF\gsm.ibn	[illegible]	0.00E+0
24	OFF	0.00	0beta_BTF\gsm.ibn	[illegible]	0.00E+0
25	OFF	0.00	0beta_BTF\gsm.ibn	[illegible]	0.00E+0
26	ON	0.00	0beta_BTF\gsm.ibn	[illegible]	0.00E+0
27	OFF	0.00	0beta_BTF\gsm.ibn	[illegible]	0.00E+0
28	ON	0.00	0beta_BTF\gsm.ibn	[illegible]	0.00E+0
29	ON	0.00	0beta_BTF\gsm.ibn	[illegible]	0.00E+0

Fig. 13-25 Possible configuration of mixed TD-SCDMA/GSM scenario

The following spectrum is obtained for the above scenario:

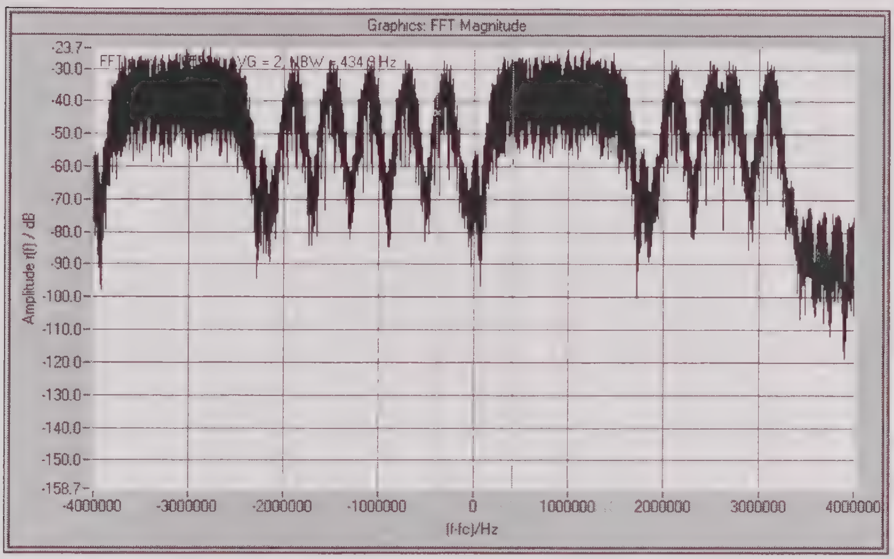


Fig. 13-26 Spectrum of mixed TD-SCDMA/GSM scenario

13.3.2.2.2 Simulation of More Than Four Cells

➢ Divide your scenario into subscenarios of max. four cells each.

➢ Configure each subscenario and store the waveforms of each scenario in a separate file.

➢ Make the following settings in the Multi Carrier Mixed Signal system:
- No. of Carriers = number of subscenarios,
- Carrier Spacing = 0,
- Super Oversampling = 1,
- Minimize Crest Factor = Off,
- all channel powers = 0 dB,
- all phases = 0°,
- all delays = 0 s.

The subscenario signals will then be added up.

13.3.2.2.3 Simulation of Delays Between Cells

➢ Generate each cell separately and store the waveforms for each cell.

➢ Make the following settings in the Multi Carrier Mixed Signal system:
- No. of Carriers = number of cells,
- Carrier Spacing = 0,
- Super Oversampling = 1,
- Minimize Crest Factor = Off,
- all channel powers = 0 dB,
- all phases = 0°,
- all delays to the desired values.

The subscenarios will then be added up time-shifted, i.e. with the delays.

14 3GPP W-CDMA TDD Mode

WinIQSIM can generate signals according to 3GPP W-CDMA TDD (3GPP TDD for short). Section 14.1 gives an overview of this mobile radio transmission method. Section 14.2 describes the associated control functions. Section 14.3 provides in-depth information about the generation of 3GPP TDD signals.

14.1 Mobile Radio Transmission Method 3GPP TDD

3GPP TDD (3rd Generation Partnership Project Time Division Duplex) designates a mobile radio transmission method developed by 3GPP (http://www.3GPP.org). The 3GPP standard is only briefly described in the following. A detailed description can be obtained from the respective 3GPP specifications (see References) that are available free of charge via the 3GPP homepage.

References:

[1] 3GPP TS 25.221 V3.6.0 (2001-03) Release 1999: Physical channels and mapping of transport channels onto physical channel (TDD)

[2] 3GPP TS 25.223 V3.5.0 (2001-03) Release 1999: Spreading and Modulation (TDD)

WinIQSIM simulates 3GPP TDD at the physical channel level. The explanations given in the following are therefore restricted to this layer.

Table 14-1 3GPP TDD parameters

Chip rate	3.84 Mcps
Carrier Spacing	5 MHz
Data modulation	QPSK
Filter	Root-raised cosine (0,22)
Channel types	Downlink : • Primary Common Control Phys. Channel (P-CCPCH) • Secondary Common Control Phys. Channel (S-CCPCH) • Primary Sync Channel (P-SCH) • Secondary Sync Channel (S-SCH) • Physical Downlink Shared Channel (PDSCH) • Page Indicator Channel (PICH) • Dedicated Phys. Channel (DPCH) Uplink : • Physical Random Access Channel (PRACH) • Physical Uplink Shared Channel (PUSCH) • Dedicated Physical Channel (DPCH)
Spreading factors	1, 2, 4, 8, 16 depending on channel type and link direction
Channel number	4 cells, each containing up to 15 active slots. Each slot with up to 16 DPCHs and 6 special channels
Frame structure	Frame: 10 ms with 15 time slots of 0.667 ms The number of symbols transmitted in a slot depends on channel type and spreading factor.
Scrambling Code	128 different codes with a length of 16 chips
Basic Midamble Codes	128 different codes with a length of 192 or 456 chips
Spreading Code	"Orthogonal Variable Spreading Factor Code (OVSF)"; spreading factors 1,2,4,8,16

3GPP TDD is a mobile radio standard in which available bandwidth is divided among subscribers according to frequency (FDMA), time (TDMA) and code (CDMA). The same frequency is used for both directions of transmission (TDD). Each resource (i.e. a combination of frequency, code and time slot) can be used simultaneously by several base or mobile stations provided the scrambling codes differ. A cell is understood to be a base station and all mobile stations communicating with this base station. WinIQSIM simulates a maximum of four cells at the same frequency.

Note: *To simulate more than four cells at the same frequency or cells at several frequencies, use the Multi Carrier Mixed Signal system (see section 14.3.2.2)*

14.1.1 3GPP TDD Signal Structure (Frames and Time Slots)

The 3GPP TDD signal is organized in frames of 10 ms length. Each frame comprises 15 time slots Ts0 to Ts14 (each 0.667 ms).

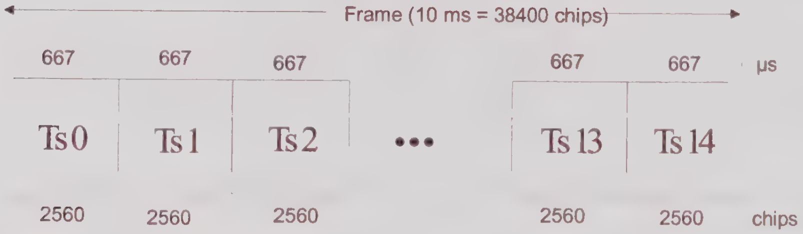
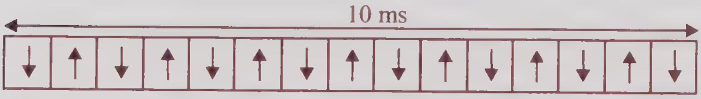
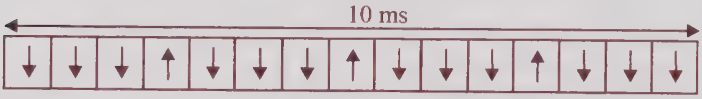


Fig. 14-1 Structure of 3GPP TDD frame

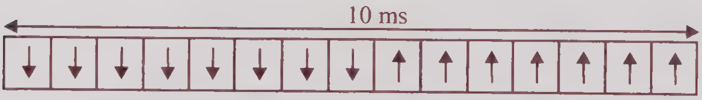
The link direction of each slot (uplink or downlink) can be determined independently of each other. However, at least one slot must usually be available for each link direction. Thus the transmission bandwidth in the TDD system can be allocated dynamically to the two link directions according to the current requirements (asymmetric DL/UL allocation).



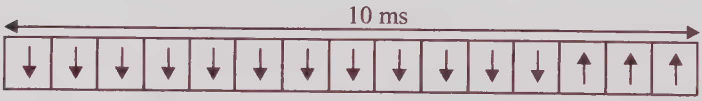
Multiple-switching-point configuration (symmetric DL/UL allocation)



Multiple-switching-point configuration (asymmetric DL/UL allocation)



Single-switching-point configuration (symmetric DL/UL allocation)



Single-switching-point configuration (asymmetric DL/UL allocation)

Fig. 14-2 Different configurations of the link directions of the slots in the 3GPP TDD frame

14.1.2 Structure of Traffic Burst

In time slots Ts0, Ts1 to Ts14, bursts can be sent by the base station or the mobile station, depending on the direction of transmission. The structure of the traffic bursts slightly differs according to the direction of transmission, the 3 following types being differentiated:

14.1.2.1 Burst Type 1

This type of burst can be used for all physical channels in the uplink and downlink. In its simplest form of implementation, it consists of two data symbols, a midamble and a guard period. To the right and left of the midamble, however, TFCI (Transport Format Combination Indicator) and, in the uplink, TPC (Transmit Power Control) information can also be transmitted, in which case the data fields are shortened accordingly.

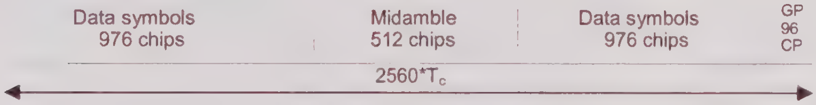


Fig. 14-3 Burst type 1 without TFCI and TPC fields

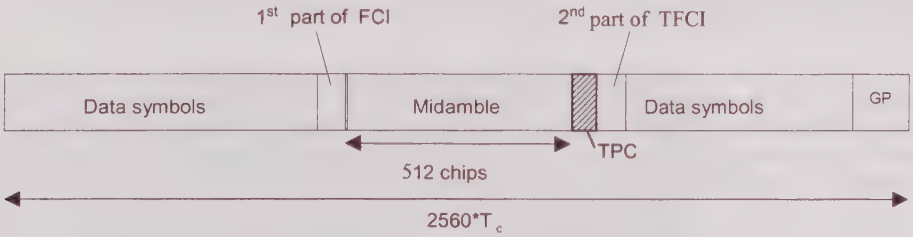


Fig. 14-4 Burst type 1 with TFCI and TPC fields

The modulation of the binary useful data into the complex chip sequence is performed as follows:

- Two consecutive useful bits are mapped via a QPSK data modulation onto a complex symbol.
- The complex symbol is shifted by n*90°, the angle depending on the spreading factor and the spreading code. For details see [2], section 6.3.
- The complex symbols are spread with a channel-specific real-valued spreading code (spreading factor SF = 1, 2, 4, 8 or 16).
  Note: In the uplink, the TFCI and TPC control information is spread with a spreading factor of 16.
- The spread symbol sequence is scrambled with a 16-chip long complex scrambling code.
- Subsequently, the scrambled sequence is weighted with the channel power.
- The chip sequences of all active code channels generated as described above are summed up and the total signal is finally applied to a baseband filter (root-raised cosine 0.22).

The midamble is obtained from the basic midamble by periodic repetition and shifting. The basic midamble is 456 chips long. There are different modes used to assign a midamble to a code channel (common, default or depending on scrambling code), for further information refer to [2]. The midamble is neither spread nor scrambled.

No signal is transmitted during the guard period. This avoids crosstalk of the burst into the next time slot at the receiver end.

14.1.2.2 Burst Type 2

Like burst type 1, burst type 2 can be used for all physical channels in the uplink and downlink. Principally, its structure is like that of burst type 1, however, the midamble is shorter (256 chips) and the data fields are therefore longer.

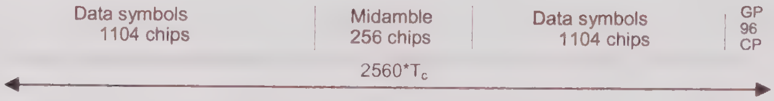


Fig. 14-5 Burst type 2 without TFCI and TPC fields

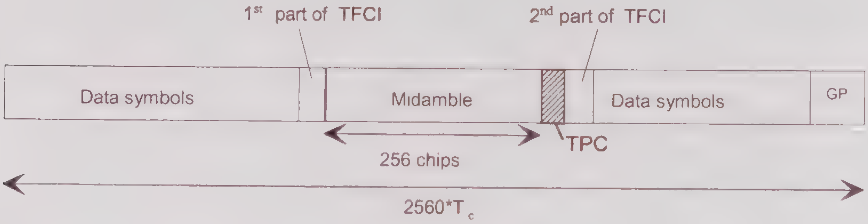


Fig. 14-6 Burst type 2 with TFCI and TPC fields

The modulation of the binary useful data into the complex chip sequence is the same as with burst type 1.

The midamble is obtained from a basic midamble by periodic repetition and shifting. The basic midamble has a length of 192 chips. There are different modes for assigning a midamble to a code channel (common, default or depending on the scrambling code), for further information refer to [2]. The midamble is neither spread nor scrambled.

14.1.2.3 Burst Type 3

This burst type can be used for all physical channels in the uplink. Principally, its structure is the same as that of burst type 1, however, the guard period is longer and the data fields are therefore shorter. The Physical Random Access Channel (PRACH) always uses burst type 3.

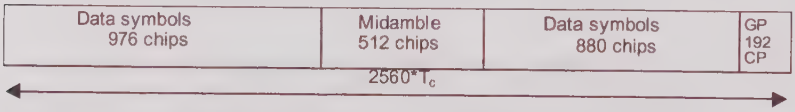


Fig. 14-7 Burst type 3 without TFCI and TPC fields

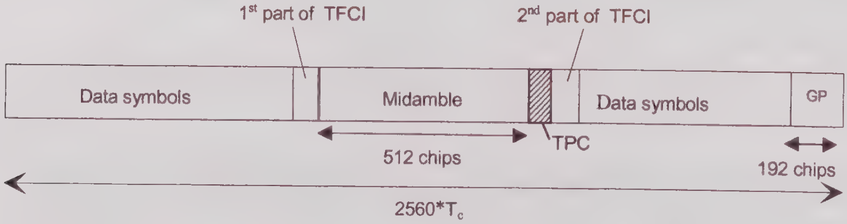


Fig. 14-8 Burst type 3 with TFCI and TPC fields

The modulation of the binary useful data into the complex chip sequence is the same as that described for burst type 1.

14.2 Generation of 3GPP TDD Signals with WinIQSIM

To generate a 3GPP TDD signal, the 3GPP W-CDMA TDD system must be selected.

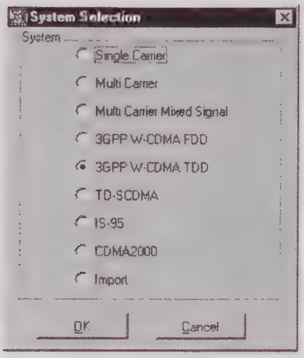


Fig. 14-9 Selection of 3GPP TDD system

The system selection menu is accessible via the "File/New..." menu or via "System!". The differences between the two methods are described in sections 5.22.1 and 5.23.

The 3GPP TDD block diagram is based on that of the single carrier system. The Data Source block has been extended and the Modulation block replaced by the TDD Configuration block.

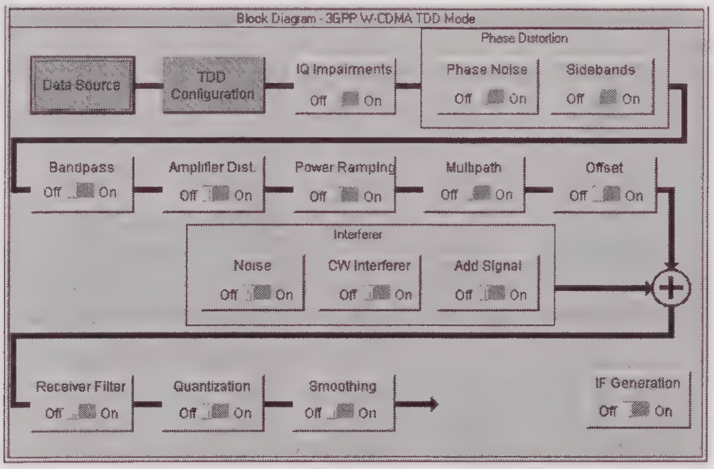


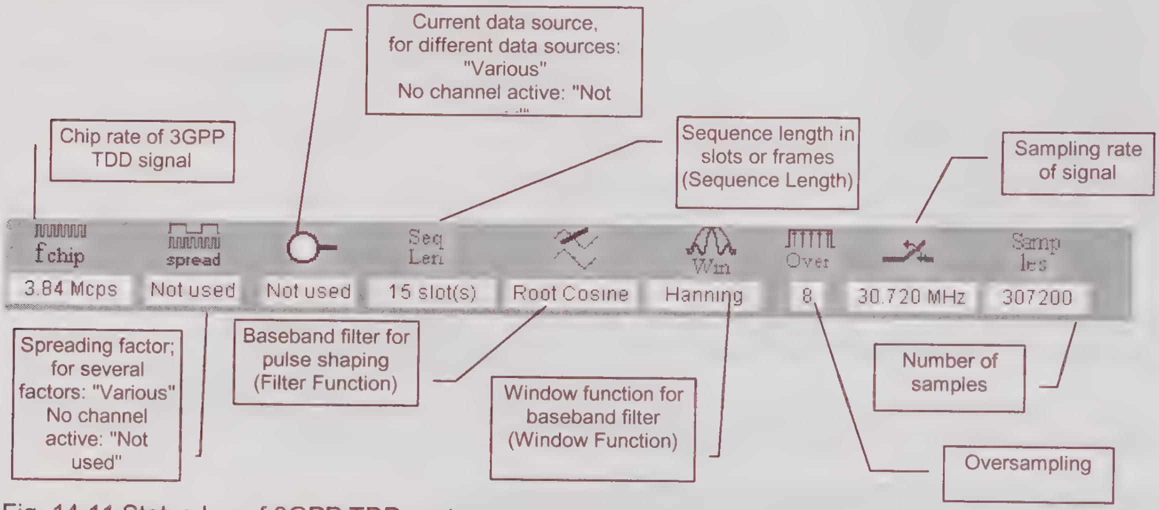
Fig. 14-10 Block diagram of 3GPP TDD system

The Data Source block corresponds to that of the Multi Carrier system. For information refer to section 7.2.

14.2.1 Status Bar

The main parameters of the 3GPP TDD transmission system are displayed in the status bar directly below the tool bar of the main panel. Thus, the set parameters can be seen at a glance.

The status bar contains icons for the different parameters. Below the icons, the current parameter values are indicated. The following illustration shows the status bar of the 3GPP TDD system with the parameters assigned to the icons.



3.84 Mcps | Not used | Not used | 15 slot(s) | Root Cosine | Hanning | 8 | 30.720 MHz | 307200

Chip rate of 3GPP TDD signal

Current data source, for different data sources: "Various" No channel active: "Not

Sequence length in slots or frames (Sequence Length)

Sampling rate of signal

Spreading factor; for several factors: "Various" No channel active: "Not used"

Baseband filter for pulse shaping (Filter Function)

Window function for baseband filter (Window Function)

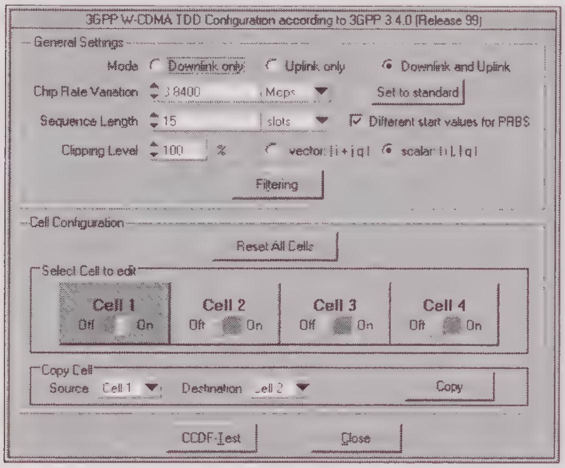
Number of samples

Oversampling

Fig. 14-11 Status bar of 3GPP TDD system

14.2.2 3GPP TDD Configuration Panel

All parameters necessary for the definition of a 3GPP TDD signal (except for data sources and impairments) can be accessed via the 3GPP TDD configuration panel.



3GPP W-CDMA TDD Configuration according to 3GPP 3.4.0 (Release 99)

General Settings

Mode ○ Downlink only ○ Uplink only ● Downlink and Uplink

Chip Rate Variation 3.8400 Mcps

Sequence Length 15 slots

☑ Different start values for PRBS

Clipping Level 100 % ○ vector: | i + j q | ● scalar: | i |, | q |

Cell Configuration

Copy Cell: Source Cell 1, Destination Cell 2

Fig. 14-12 3GPP TDD Configuration panel

14.2.2.1 General Settings

The following parameters are defined in the General Settings panel:

- **Mode**
  Here it is defined whether only the base station (downlink only) or only the mobile stations (uplink only) or both types of station (downlink and uplink) should be active in a cell.

- **Chip Rate Variation**
  This parameter allows changing the output chip rate (i.e. the rate of spread symbols used for signal output by AMIQ, for example) as against the standard chip rate of 3.84 Mcps. The standard chip rate of 3.84 Mcps can be restored any time by means of the **Set to standard** button.

- **Sequence Length**
  The length of the signal to be generated can be set here. It can be entered either in slots (2560 chips, 0.667 ms) or frames (38.400 chips, 10 ms).
  When the length unit is changed, the indicated numerical value is automatically converted into the new unit (1 frame corresponds to 15 slots). When changing from slots to frames, the value is rounded up to the next highest whole frame number.

- **Different start values for PRBS**
  If this button is active, the PRBS generators of the individual channels are initialised with different start values. As a result, all channels are calculated with independent source data.

  Note: *This button is effective only for the data source designated "Data Source PRBS". If, for example, "Data Source 0" with PRBS16 is used, the button is ignored, i.e. all channels using Data Source 0 are calculated with identical PRBS bit sequences!*

- **Clipping Level**
  A clipping value can be set as a percentage of the highest peak. The range is 1 to 100 %.
  A value of 100 % means that the signal is not clipped. Clipping reduces the crest factor. Two different methods of clipping are offered:

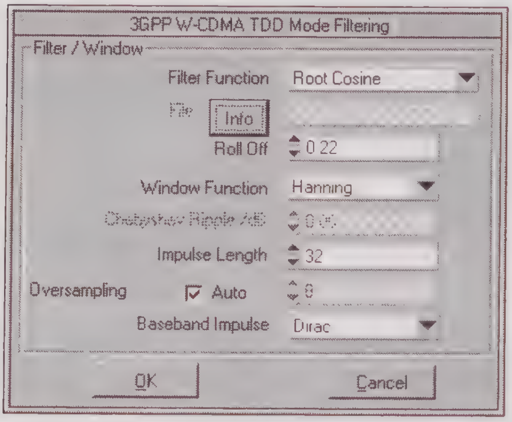
  vector | i+jq | : The instantaneous amplitudes | i+jq | are used as peak values

  scalar | i |,| q | : The absolute maximum of all I and Q values is used as peak value

  For more detailed information on this parameter see section 14.2.2.7.

14.2.2.2 Filtering

The raw chips generated are subjected to baseband filtering which is implemented as in the case of the Single Carrier system.



Filter Function: Root Cosine
Roll Off: 0 22
Window Function: Hanning
Impulse Length: 32
Oversampling ☑ Auto: 8
Baseband Impulse: Dirac

Fig. 14-13 3GPP TDD Filtering

For a description of the individual parameters, therefore, refer to section 5.8 " Modulation Settings Panel".

For the filtering of 3GPP TDD signals, the parameter settings shown in Fig. 14-13 are recommended.

14.2.2.3 Cell Configuration

The 3GPP TDD system can simulate signals for up to four cells.

14.2.2.3.1 Common Setting of All Cells

The Cell Configuration panel (see Fig. 14-12) comprises several buttons :

- **Reset All Cells**
  All cells are reset to predefined settings, which are shown in the table below.

Table 14-2 Reset values for cells

Common parameters of cells	Reset value
State	Off
Scrambling Code	0
Scrambling Code Off	If button deactivated, scrambling code is active
Code Group	0
Midamble allocation method	default
Guard field power state	Off (according to standard)
Parameters of slots	**Reset value**
State	Off
Slot Mode	Uplink Dedicated
TPC Pattern Read Out Mode	Continuous
Burst Type	Burst Type 1
SCH assoc. t_offset	0 (only downlink)
SCH code allocation	case 1 (only downlink)
PI Length	Lpi = 2 (only downlink)
Parameters of channels	**Reset value**
User	1
Spreading factor	SF 16
Spreading Code	1
Midamble Shift	not active
TFCI/TPC Combi	TFCI 0 or TFCI 0 / TPC 0
TFCI	0
TPC Pattern	"0" (only uplink)
Power	0 dB
Data Source	PRBS for all channels
State	Off for all channels

- **Select Cell to edit**
  In this panel, the cells are shown as blocks. They can be switched on or off. Active cells are highlighted green, passive cells are shown grey. So you can see at a glance which cells are currently active. If you wish to edit the parameters of a cell, simply click the corresponding block. A window for configuring the cell parameters opens (see section 14.2.2.3.2)
- **Copy Cell**
  This panel allows you to copy the configuration of a cell to another cell. In the Source field select the cell to be copied, in the Destination field the cell to be overwritten. Start copying by clicking the Copy button. You can thus easily create a scenario of several cells after having configured one cell. After copying, only the cell-specific parameters such as scrambling code have to be changed to simulate different cells.
- **Close**
  If this button is selected, the 3GPP TDD Configuration panel is closed.

14.2.2.3.2 CCDF Test

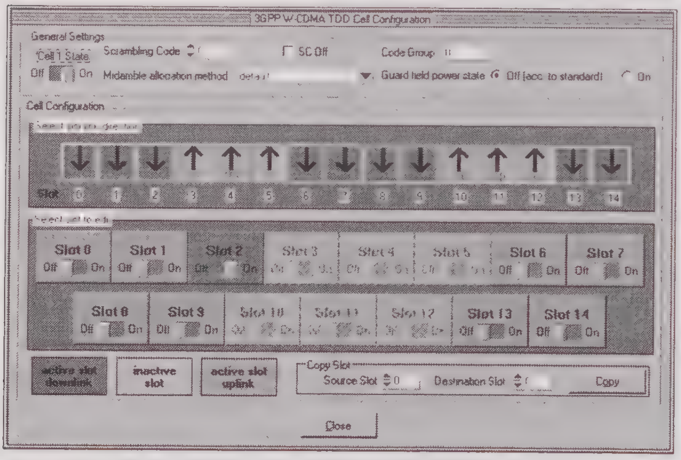
This button opens a window in which a complementary cumulative distribution function (CCDF) is displayed. For details see section 8.2.2.7.

The CCDF panel of the TDD mode offers more options than that of the FDD mode. In the FDD mode, the CCDF over the complete signal is of interest (the signal contains no bursts). In the TDD mode, where transmission takes place in timeslots that can be switched independently, only the CCDF of an active slot is of interest in many cases. This function can be used, for example, to optimally adjust the output amplifier of a mobile, which is also active in one slot only.

The following CCDF modes are available:

- **Complete signal**: The CCDF is calculated over the complete I/Q signal, same as with 3GPP FDD.
- **Specific slot including guard**: The CCDF is calculated over the signal range of the selected timeslot (**Slot Index** field), including the guard interval.
- **Specific slot excluding guard (96 chips)**: The CCDF is calculated over the signal range of the selected timeslot (**Slot Index** field), excluding the 96-chip guard interval at the end of the slot.
- **Specific slot excluding guard (192 chips)**: The CCDF is calculated over the signal range of the selected timeslot (**Slot Index** field), excluding the 192-chip guard interval at the end of the slot.

The following figures illustrate the basic differences between the CCDF modes. A TDD signal with a length of one frame and with one active slot is selected as a test scenario.

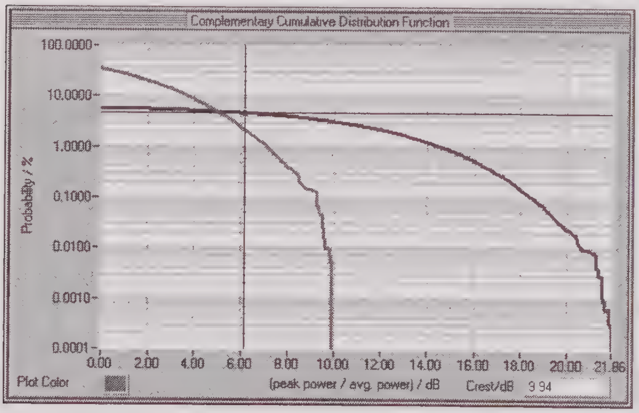


Midamble allocation method default

Guard field power state ● Off (acc. to standard) ○ On

Source Slot 0

Fig. 14-14 Test scenario illustrating the different CCDF modes



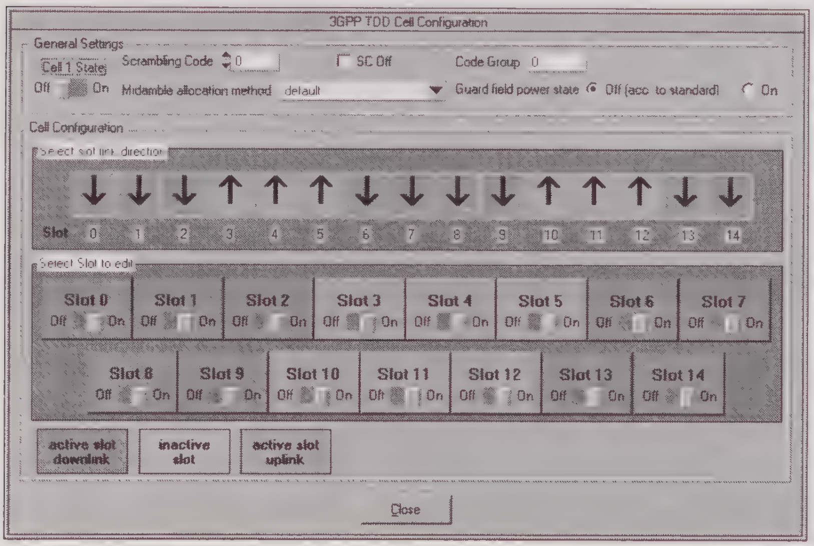
Crest/dB 9.94

Fig. 14-15 CCDF traces in "complete signal" mode and "specific slot excluding guard" mode

The CCDF significantly changes already on account of the different calculation periods. In the above example, the crest factor in the relevant signal range (active slot 2) is approx. 10 dB, whereas the crest factor over the complete signal is approx. 22 dB (the large number of inactive slots reduces the RMS value and thus, with constant peak, increases the crest factor).

14.2.2.4 3GPP TDD Cell Configuration Panel

If you click one of the cell blocks in the 3GPP TDD Configuration panel, the Cell Configuration Panel is opened. The 3GPP TDD Configuration panel is displayed at the same time but is dimmed since the two windows are interrelated in many ways. The 3GPP TDD Configuration parameters can be read but not changed. When the Cell Configuration panel is closed (Close), the 3GPP TDD Configuration panel is enabled again.



3GPP TDD Cell Configuration

General Settings

Scrambling Code 0

☐ SC Off

Code Group 0

Midamble allocation method default

Guard field power state ● Off (acc. to standard) ○ On

Fig. 14-16 3GPP TDD Cell Configuration panel

14.2.2.4.1 General Cell Settings

In this section, parameters valid for the complete cell can be set.

- **Cell State**
  The complete cell can be switched on or off.
- **Scrambling Code**
  The scrambling code is used for transmitter-dependent scrambling of the chip sequence.
  The range of the scrambling code is 0 to 127.
- **SC Off**
  If this button is active, the scrambling code is deactivated for test purposes.
- **Code Group**
  The code group is automatically set so that it matches the scrambling code. The dependence of the code group on the scrambling code is defined in [2].
- **Midamble Allocation Method** : Three modes are available for defining the midamble of the code channels. A detailed description of the methods is to be found in [1] in section 5.6 "Midamble Allocation for Physical Channels"
  - **default**: The basic midamble used results from the channelization or spreading codes of the channel.
  - **common**: The basic midamble used results from the number of channelization or spreading codes used in a slot and the number of users in a slot.

- **equal to scrambling code**: The basic midamble used directly results from the scrambling code of the cell (see [2] section 7.3 "Evaluation of synchronization codes").

Irrespective of the allocation method selected, the midamble of a code channel is generated from the periodically continued basic midamble and a time shift (midamble shift). The midamble shift, in turn, depends on the user index and/or number of active users. Since this selection of the basic midamble and the midamble shift used is relatively complex, the channel table (Slot Configuration panel) indicates the index of the basic midamble used (see [1] Annex A) and the midamble shift.

- **Guard field power state**: Here you can define whether the power is to be blanked or not in the Guard field.
  - **Off (according to standard)**: The Guard field is blanked as defined in the TDD standard (no power).
  - **On**: The Guard field is not blanked and features the same power as the rest of the slot. 0 bits are sent as useful data in the Guard field. This function can be used to suppress bursting and power ramping for the first tests with 3GPP TDD.

14.2.2.5 Cell Configuration

The Cell Configuration panel consists of two parts:

- **Select slot link direction**
  Here, you can define for each slot whether it is to be used for the uplink or downlink. To this end, simply press the up/down symbols of the slots.

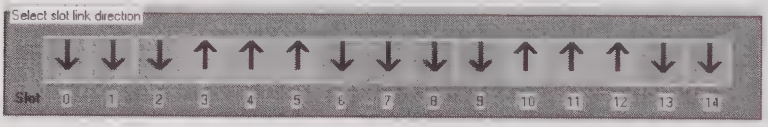

Select slot link direction
↓ ↓ ↓ ↑ ↑ ↑ ↓ ↓ ↓ ↓ ↑ ↑ ↑ ↓ ↓
Slot 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

Fig. 14-17 Select slot link direction

- **Select slot to edit**
  Here, the slots are represented as blocks. They can be switched on or off. Active slots are highlighted green (downlink) or cyan (uplink), inactive slots are shown grey. Slots that are blanked because of the set mode (Uplink Only, Downlink Only or Downlink and Uplink) are additionally dimmed.
  So you can see at a glance which slots are currently active and whether they are downlink or uplink slots. If you wish to edit the parameters of a slot, simply click the corresponding block. The slot configuring panel opens.

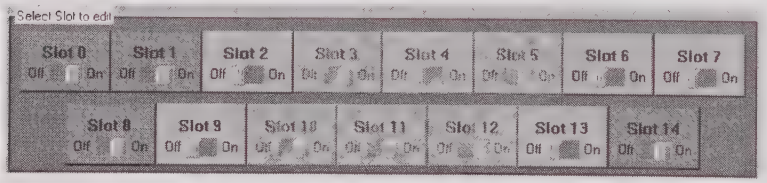


Fig. 14-18 Select slot to edit

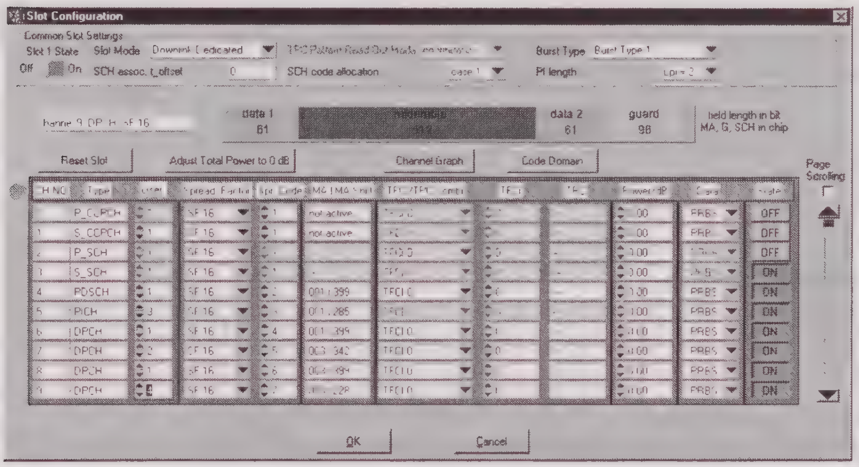
- **Copy Slot**
  In this panel you can copy a given slot configuration to another slot. In the Source Slot field, select the slot to be copied, and in the Destination Slot field the slot to be overwritten. Start the operation with the Copy button. In this way you can easily generate a scenario of several slots after configuring one slot.

Close
On clicking this button, the 3GPP TDD Cell Configuration panel is closed.

14.2.2.6 Slot Configuration Panel in Dedicated Mode

If you click one of the slot blocks in the 3GPP TDD Cell Configuration panel, the Slot Configuration panel opens. The 3GPP TDD Cell Configuration panel remains displayed in the background but is not accessible since the two windows are interrelated in many ways. When the Slot Configuration panel is closed (OK or Cancel), the 3GPP TDD Cell Configuration panel is enabled again.

In the downlink or uplink (mode = Uplink Dedicated), several channels can be simulated at the same time. In the downlink, all channels come from a base station and are directed either at all mobile stations (e.g. P-CCPCH) or at different mobile stations specifically (DPCH). In the uplink, DPCHs are simulated that transmit to the only base station of the cell.



Slot 1 State: Off ● On
Slot Mode: Downlink Dedicated
TPC Pattern Read Out Mode: [illegible]
Burst Type: Burst Type 1
SCH assoc. t_offset: 0
SCH code allocation: case 1
PI length: Lpi = 2

Channel 9 DPCH SF 16

data 1	midamble	data 2	guard	field length in bit MA, G, SCH in chip
61	[illegible]	61	96	

CH NO	Type	User	Spread Factor	Spr Code	MA / MA Shift	TFCI / TPC	TF..	TF..	Power / dB	Data	State
	P_CCPCH	[illegible]	SF 16	1	not active	[illegible]	[illegible]		[illegible]00	[illegible]	OFF
1	S_CCPCH	1	SF 16	1	not active	[illegible]			[illegible]00	[illegible]	OFF
2	P_SCH	1	SF 16	-		[illegible]	0	-	0.00	[illegible]	OFF
3	S_SCH	1	SF 16	1	-	[illegible]		-	0.00	[illegible]	ON
4	PDSCH	1	SF 16	2	001 / 399	TFCI 0	0		0.00	PRBS	ON
5	PICH	3	SF 16	[illegible]	001 / 285	[illegible]	[illegible]	-	0.00	PRBS	ON
6	DPCH	1	SF 16	4	001 / 399	TFCI 0	1		0.00	PRBS	ON
7	DPCH	2	SF 16	5	003 / 342	TFCI 0	0		0.00	PRBS	ON
8	DPCH	1	SF 16	6	004 / 394	TFCI 0			0.00	PRBS	ON
9	DPCH	4	SF 16	7	[illegible] 228	TFCI 0	1		0.00	PRBS	ON

Fig. 14-19 Slot Configuration panel

- **Slot State**
  The complete slot can be switched on or off.
- **Slot Mode**
  If the slot is allocated to the downlink, the mode is fixed at "Downlink Dedicated".
  In the uplink, the slot can be used for simulation either in the dedicated mode (call established) or in the PRACH mode. In the dedicated mode, several mobile stations can be simulated, in the PRACH mode only one.
- **TPC Pattern Read Out Mode (only uplink)**
  The TPC bits are used to signal to the other station that the transmit power is increased or reduced. The TPC field can be defined independently for each channel of the slot in the channel table of this panel. The TPC Pattern Read Out Mode parameter defines how the bit pattern is to be used.
  The following modes are available:

  - **Continuous**: From the bit pattern (max. 16 bits) for the transmit power control field of the slots, 1 bits is taken for each slot and introduced in the bit stream several times (depending on the length of the TPC field). The specified bit pattern is used cyclically.
  - **Single + All 0**: From the bit pattern (max. 16 bits) for the transmit power control field of the slots, one bit is taken for each slot and introduced in the bit stream several times (depending on the length of the TPC field). The specified bit pattern is used once, then the TPC sequence is continued with "0" bits.
  - **Single + All 1**: From the bit pattern (max. 16 bits) for the transmit power control field of the slots, one bit is taken for each slot and introduced in the bit stream several times (depending on the length of the TPC field). The specified bit pattern is used once, then the TPC sequence is continued with "1" bits.

- **Single + alt. 01**: From the bit pattern (max. 16 bits) for the transmit power control field of the slots, one bit is taken for each slot and introduced in the bit stream several times (depending on the length of the TPC field). The specified bit pattern is used once, then the TPC sequence is continued with alternating "0" and "1" bits (multiplied depending on the length of the TPC field, e.g. 00001111).
- **Single + alt. 10**: From the bit pattern (max. 16 bits) for the transmit power control field of the slots, one bit is taken for each slot and introduced in the bit stream several times (depending on the length of the TPC field). The specified bit pattern is used once, then the TPC sequence is continued with alternating "1" and "0" bits (multiplied depending on the length of the TPC field, e.g. 11110000).

The different modes can be used, for example, to set a mobile to a defined output power (e.g. with pattern 11111) and maintain this power (with **Single + alt. 01** or **Single + alt. 10**). This allows power measurements on the base station (with constant power in this case).

- **Burst Type**
  Three different burst types are defined in the TDD standard. The burst types differ from each other in the length of the midamble and of the guard interval (see also 14.1.2).
  In the Downlink Dedicated Mode burst types 1 and 2 are available, in the Uplink Dedicated Mode burst types 1, 2 and 3.
- **SCH assoc. t_offset (only in downlink)**
  This parameter indicates the time shift of the SCH at the start of the slot (see [1] section 5.3.4 The synchronization channel). The parameter value cannot be set, it directly depends on the scrambling code or the code group.
- **SCH code allocation (only in downlink)**
  This parameter permits to determine the mode for defining the code for the SCH (see [2] section 7.2 Code Allocation). The modes Case 1 and Case 2 defined in the standard are available.
- **PI Length (only in downlink)**
  The length of the paging indicator for the PICH is defined here. The lengths 2, 4 and 8 are offered.

Slot structure
The Common Slot Settings panels displays the slot structure of the code channel that is currently being edited in the channel table. In the left-hand text field, the channel number in the table, the type of channel and its spreading factor are entered. Thus you can see at a glance how changing a parameter like burst type and spreading factor affects the slot structure.
The slot display contains the name of a slot field and its length. The length is usually indicated in bits, however, in the Midamble and Guard fields, it is indicated in chips as defined in the standard.

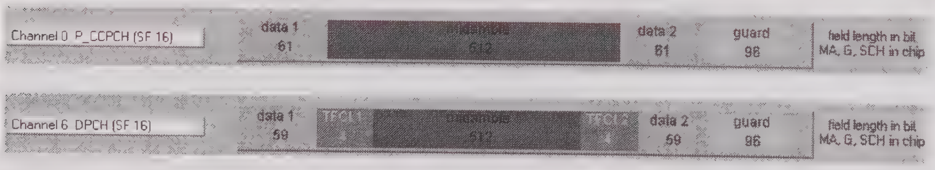
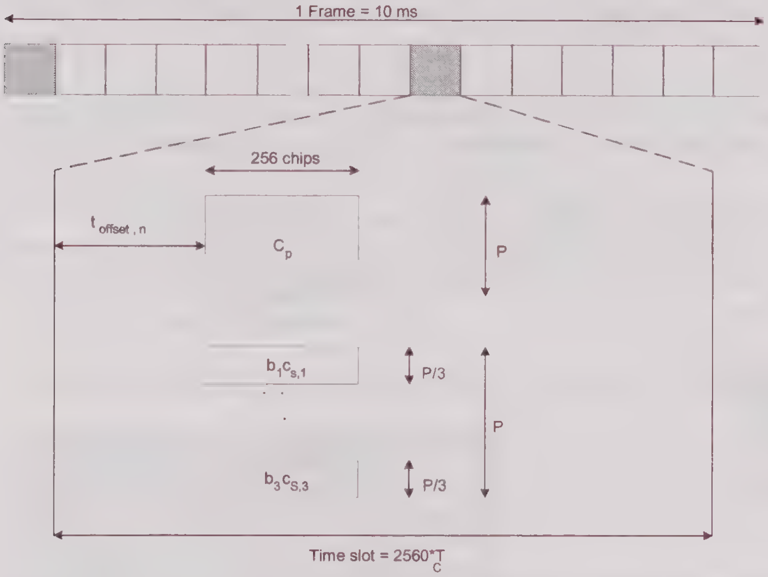


Fig. 14-20 Display of slot structure for different channels

Special features of the secondary SCH

The 3GPP TDD standard defines 3 S-SCHs. They are generated in WinIQSIM™ as defined in the standard. However, for the sake of ease of use and clarity, they cannot be configured separately. By activating the S-SCH in the channel table, all 3 S-SCHs are automatically generated as defined in the standard. The channel power of the 3 S-SCHs is 1/3 of the power value set in the channel table. See also [1] section 5.3.4 The synchronization channel (SCH).



$C_{s,i} \in \{C_0, C_1, C_3, C_4, C_5, C_6, C_8, C_{10}, C_{12}, C_{13}, C_{14}, C_{15}\}$, i=1,2,3; see [8]

Fig. 14-21 Structure of SCH consisting of P-SCH and 3 S-SCHs

14.2.2.6.1 Channel Table of a Slot

The major part of the Slot Configuration panel is taken up by the scrollable channel table. The table elements can be edited directly. The parameters shown in the table columns are explained below.

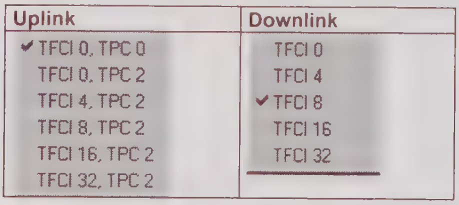
- **CH NO**
  In the first column, consecutive channel numbers starting with 0 are displayed. A WinIQSIM base station comprises special channels, such as P-CCPCH, and 16 DPCHs. All channels can be configured separately.
- **Type**
  The channel type is displayed. The first code channels of the table are reserved for special channels P-CCPCH, S-CCPCH, P-SCH, S-SCH, PDSCH and PICH in the downlink and PUSCH in the uplink. The remaining code channels are DPCHs. The channel type is displayed for information only; it cannot be edited.
- **User**
  In this column, the code channel can be allocated to a user. The user index and the number of active users affects the selection of the midamble and the midamble shift. The value range depends on the burst type. For burst types 1 and 3, the maximum number of users is 16, for burst type 2 a maximum of 6 users is permissible.

- **Spreading Factor**
  The spreading factor of the code channel can be determined. The possible spreading factors depend on the channel type and the link direction. For uplink DPCHs, for example, all spreading factors 1, 2, 4, 8, and 16 defined in the standard are possible, whereas only 1 and 16 are permissible in the downlink.

- **Spr. Code**
  The spreading code can be selected. The value range depends on the spreading factor of the channel and partly on the channel type as well.
  The maximum range is 1 to the spreading factor.

- **Midamble | Midamble Shift**
  In this column, the midamble used in the channel and the associated midamble shift are displayed. See also section 14.2.2.4.1. When the channel is deactivated, "not active" is displayed.

- **TFCI / TPC Combi**
  Here, the combination of the TFCI and TPC fields can be set for each code channel. For more detailed information refer to [1] in section 5.2.2.6 Timeslot formats. In the uplink, the slot may contain both a TFCI and a TPC field, in the downlink only a TFCI field. The following combinations of TFCI and TPC field lengths are provided:



Uplink	Downlink
✓ TFCI 0, TPC 0	TFCI 0
TFCI 0, TPC 2	TFCI 4
TFCI 4, TPC 2	✓ TFCI 8
TFCI 8, TPC 2	TFCI 16
TFCI 16, TPC 2	TFCI 32
TFCI 32, TPC 2	

- **TFCI**
  In this column, the Transport Format Combination Indicator of the code channel can be set. The range is 0 to 1023.

- **TPC (only uplink)**
  In this field, you can enter a pattern of max. 16 bits for the transmit power control field of the slots. One bit per slot is taken from this pattern and introduced into the bit stream several times (depending on the TFCI/TPC combination). The specified bit pattern is used in accordance with the selected TPC Pattern Read Out Mode (see section14.2.2.6).

- **Power/dB**
  The power of the code channels can be set between –60 dB and 0 dB.

- **Data**
  One of four data sources (Data 0, Data 1, Data 2 or PRBS) can be selected. For a description of the data sources see section 7.2. The Data field is not accessible for channel types that contain no data fields (e.g. P-SCH).

- **State**
  With this button you can select whether or not a given code channel should be included in your signal scenario. The State buttons of the active channels are highlighted green, so you can identify the active channels at a glance.

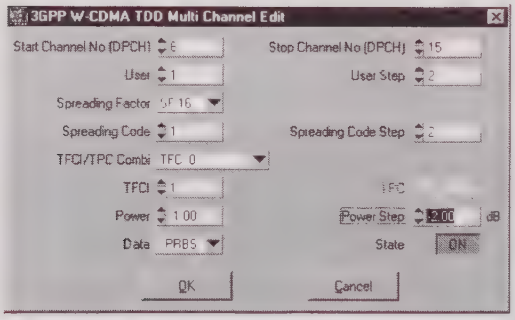
The scrollbar next to the table allows scrolling up and down the table. The following modes are supported:

Table 14-3 Scrollbar modes

Function	Actions
Scrolling the table line by line	- Switch off Page Scrolling ☐ Page Scrolling - Click the large arrows ▲, ▼ or – Click the black box ■ -> scrollbar is activated – Press <Up> / <Down> cursor keys
Scrolling the table page by page	- Switch on Page Scrolling ☑ Page Scrolling - Click the large arrows ▲, ▼
Jumping to any position in the table	- Click black box ■ (keep mouse key pressed) – Move to desired position – Release left-hand mouse key

14.2.2.6.2 Multi Channel Edit

The Multi Channel Edit button opens a window in which several DPCHs can be configured jointly.



Start Channel No (DPCH) 6
Stop Channel No (DPCH) 15
User 1
User Step 2
Spreading Factor SF 16
Spreading Code 1
Spreading Code Step 2
TFCI/TPC Combi TFC 0
TFCI 1
Power 1.00
Power Step 2.00 dB
Data PRBS
State ON

Fig. 14-22 3GPP W-CDMA TDD Multi Channel Edit panel

In this panel, you can set all parameters of the channel table for a group of DPCHs. The value ranges of the DPCH parameters correspond to those of the associated channel table parameters (see above).

Start Channel No (DPCH)/Stop Channel No (DPCH): Here you define the range of DPCHs to be configured jointly.

Complete channel scenarios can be configured simply by entering start values and step widths for some channel parameters. For example, you can use the **Spreading Code** and **Spreading Code Step** parameters to assign spreading codes at a fixed step width to the individual code channels. Analogously, you can create power profiles over the code axis with **Power** and **Power Step**. With **User** and **User Step**, you can assign channels to different users.

14.2.2.6.3 Reset Slot Table

With the Reset Slot Table button, you can reset the channel table parameters of the slot to defined settings. This does not affect the parameters of the Common Slot Settings panel. The reset values are shown in the following table.

Table 14-4 Reset values of slot table

Parameters of code channels	Reset value for all channels
User	1
Spreading Factor	SF 16
Spreading Code	1
Midamble | Midamble Shift	not active
TFCI / TPC Combi	TFCI 0 or TFCI 0 / TPC 0
TFCI	0
TPC Pattern	"0"
Power	0 dB
Data Source	PRBS
State	Off

14.2.2.6.4 Adjust Total Power to 0 dB

The power of the individual code channels is set so that the total power of all active channels is 0 dB. The set power differences between the channels remain the same but the total power is normalized to 0 dB. This mode can be used to send the individual code channels precisely with the power defined in WinIQSIM from Signal Generator SMIQ (with a set rms transmit power of 0 dB). The pulse duty factor of the individual channels (the SCH e.g. is active in 10% of the slot only) is taken into account.

14.2.2.6.5 Channel Graph

This graph shows all active channels at a glance.

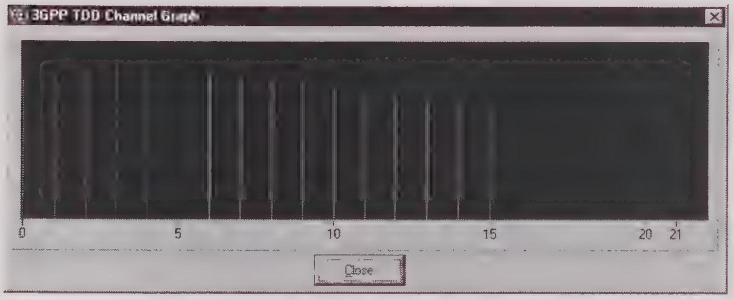


Fig. 14-23 Channel Graph

The special channels (P-CCPCH, S-CCPCH, P-SCH, S-SCH, PDSCH and PICH in the downlink, PUSCH in the uplink) are shown by red lines, the DPCHs by green lines. The length of the lines indicates the channel power.

14.2.2.6.6 Code Domain

This graph shows all active channels in the code domain.

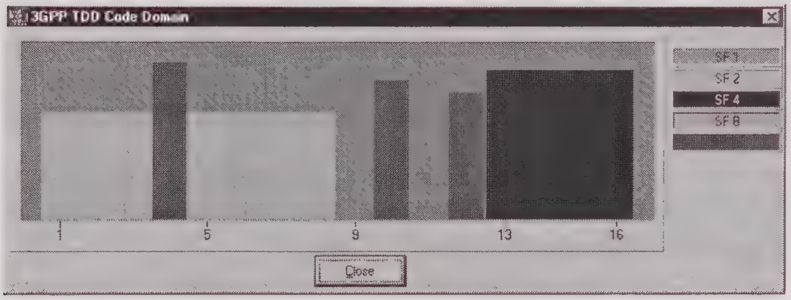
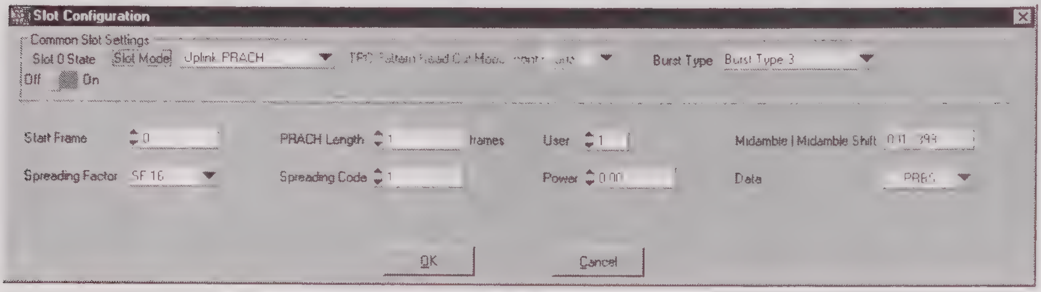


Fig. 14-24 Code Domain Display

This graph as well as the signaling and resolving of code domain conflicts are described in section 8.2.2.5.6. In contrast to the FDD mode of 3GPP, the spreading code indices do not start with 0 but with 1. Therefore, for spreading code 4, there are the spreading codes 1, 2, 3 and 4. Apart from this small difference, the display and resolution of domain conflicts in TDD mode is the same as described for FDD.

14.2.2.6.7 Settings of Slot Configuration Panel in PRACH Mode

When changing the slot mode from Uplink Dedicated to Uplink PRACH, the appearance of the panel changes as follows:



Slot Mode: Uplink PRACH
Burst Type: Burst Type 3
Start Frame: 0
PRACH Length: 1 frames
User: 1
Midamble | Midamble Shift: 0 | 1 393
Spreading Factor: SF 16
Spreading Code: 1
Power: 0.00
Data: PRBS

Fig. 14-25 Slot Configuration panel in PRACH mode

In PRACH mode, a random access burst is simulated whose start point and length can be determined. For the PRACH, burst type 3 is defined in the standard. The following parameters can be set in PRACH mode:

- **Start Frame**
  This parameter defines the frame in which the PRACH starts.
  The range of the start frame is 0 to 10.
- **PRACH Length**
  Length of the PRACH burst in frames (1 to 10).
- **User**
  Selection of the user for whom the PRACH is to be sent. The user index affects the selection of the midamble and midamble shift. The value range for burst type 3 is 1 to 16.
- **Midamble | Midamble Shift**
  This column displays the midamble used in the channel and the associated midamble shift. See also section 14.2.2.4.1. When the channel is deactivated, "not active" is displayed.
- **Spreading Factor**
  In this column, the spreading factor of the PRACH can be determined. Spreading factors 8 and 16 are possible for the PRACH.
- **Spr. Code**
  The spreading code for the PRACH can be selected. The range depends on the spreading factor of the PRACH.
  The maximum range is 1 to the spreading factor.
- **Power/dB**
  The power of the PRACH can be set in this column. The value range of the channel power is –60 dB to 0 dB.
- **Data**
  Selection of one of the four data sources Data 0, Data 1, Data 2 or PRBS. For the definition of the data sources refer to section 7.2.

14.2.2.7 Effect of the CLIPPING LEVEL Parameter on the Signal

The envelope of a 3GPP TDD signal comprises three parts:

- active slots in the downlink
- active slots in the uplink
- inactive slots

WinIQSIM evaluates all three parts in average, peak and CCDF calculation. Depending on their position in the signal path, certain system components only "see" certain sections of the frame, so that different values are obtained for CCDF for example.

Example: *For the antenna at the receive end the complete signal is relevant, at the transmit end only the active slots in the direction of transmission.*

3GPP TDD signals may have very large crest factors, in particular if a large number of channels and many inactive slots are involved. Large crest factors entail two basic problems:

1. Nonlinearity of the power amplifiers (compression) causes intermodulation, which expands the spectrum (spectral regrowth).
2. Since the D/A converters are driven with an orientation to the maximum value, average-value conversion takes place with relatively low resolution. The result is high quantization noise.

Each of these effects increases adjacent-channel power.

The simplest and most effective way of reducing the crest factor (often also referred to as peak-to-average ratio or PAR) is by changing the clipping level. The clipping level is a limit value expressed as a percentage of the highest peak value.
All instantaneous values exceeding the limit value are reduced to this value. Clipping is done prior to filtering so that it has no negative effect on the spectrum. EVM increases however.

Since clipping of the signal not only changes the peak but also the average values, its effect on the crest factor is not immediately predictable. The following table shows the effect of the clipping level on the crest factor for some typical scenarios:

Table 14-5 Change of crest factor through clipping

CLIPPING LEVEL (mode vector)	**Crest factor with scenario**			
	2 active downlink slots each with 8 active code channels **Sequence length 15 slots (1 frame)**	**2 active downlink slots each with 8 active code channels** **Sequence length 2 slots**	**2 active downlink slots each with 16 active code channels** **Sequence length 15 slots (1 frame)**	**2 active downlink slots each with 16 active code channels** **Sequence length 2 slots**
100 %	18.7 dB	9.9 dB	21.0 dB	12.3 dB
80 %	17.4 dB	8.6 dB	19.3 dB	10.5 dB
60 %	16.4 dB	7.6 dB	17.9 dB	9.2 dB
40 %	15.2 dB	6.4 dB	17.1 dB	8.3 dB
20 %	14.2 dB	5.5 dB	14.8 dB	6.0 dB
10 %	13.9 dB	5.2 dB	14.1 dB	5.4 dB

Other settings:

- Spreading factor 16
- Clipping type "vector"
- Filter "Root Cosine 0.22"

Apart from the effect of clipping and the channel number on the crest factor, the effect of the monitoring period also becomes evident in the above table.

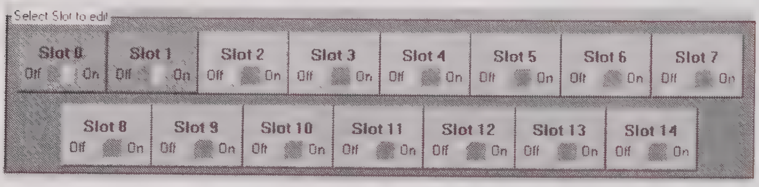


Fig. 14-26 Frame with 2 active slots

When activating 2 slots (see Table 14-5) and determining the crest factor over the whole frame, the average value of the signal power is reduced due to the inactive slots; the peak of the power is not affected by the inactive slots. Thus the crest factor is clearly higher (in the example by up to 9 dB) than when considering only the two active slots.

Effect of clipping on the constellation for a 10-DPCH configuration:

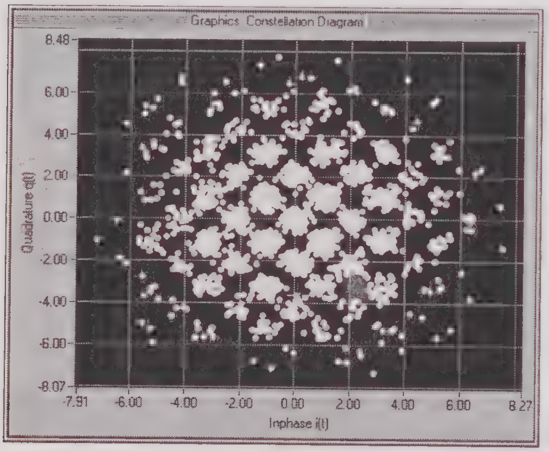


Fig. 14-27 Constellation for 100 % clipping level (no clipping)

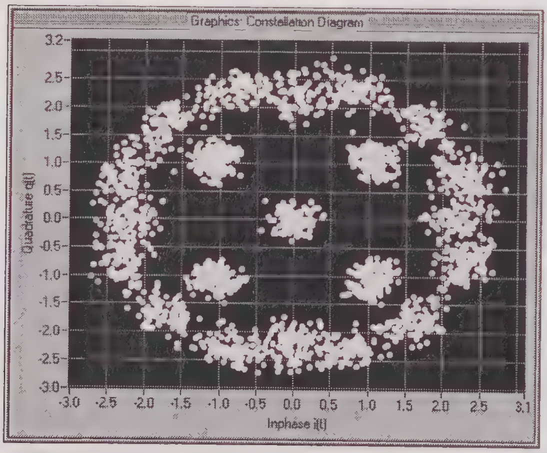


Fig. 14-28 Constellation for 30 % clipping level (vector)

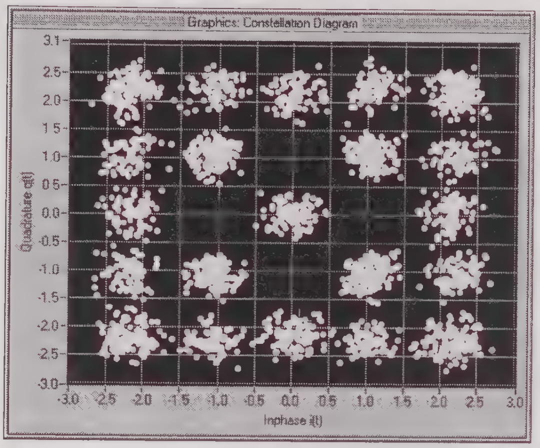


Fig. 14-29 Constellation for 30 % clipping level (scalar)

14.3 Further Information for the Generation of 3GPP TDD Signals

14.3.1 3GPP TDD Signals Shown in Time Domain and Constellation Display

P-CCPCH and PRACH
In the following a signal with a P-CCPCH in slot 0 and a PRACH in slot 1 is to be generated.
Other settings:

- Sequence length = 3 frames
- Filtering: Root Cosine (Roll Off = 0.22), pulse length = 32, oversampling = 4
- Data source: PRBS9
- No superimposed impairments active
- Channel powers P-CCPCH 0 dB
- Channel power PRACH 0 dB, start frame 0, PRACH length 2 frames

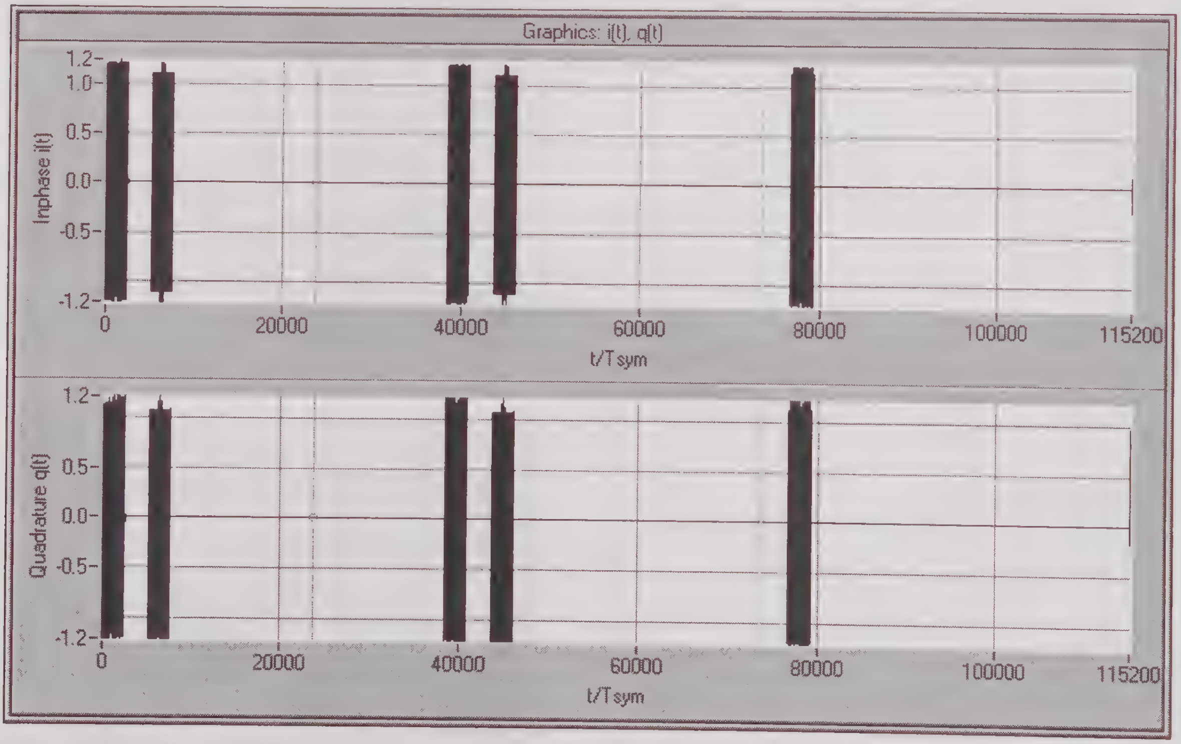


Fig. 14-30 Time-domain display of signal comprising a P-CCPCH and a PRACH

The above display shows three frames of 38400 chips each. In all three frames, slot 0 (P-CCPCH) is active. In addition the PRACH can be recognized in slot 2 in frame 0 and 1. As a result of the PRACH parameter setting start frame 0 and length 2 frames the PRACH is transmitted in the first two frames only.

Note: *In the following, filtering is changed to "Rect" to provide a clearer display of powers and time characteristics.*

Effect of the midamble on signals with several DPCHs in one slot
In the following, a signal with 8 active DPCHs in the first slot is investigated. In the first scenario, all active code channels of the slot are allocated to the user. Thus, all code channels get the same midamble and the same midamble shift.

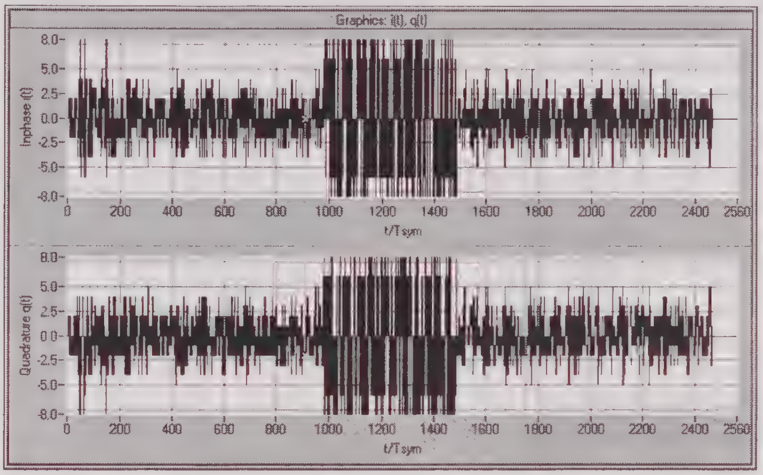


Fig. 14-31 Time-domain display of a signal comprising 8 DPCHs allocated to one user

When looking closer at the time-domain signal of this 8 DPCH scenario, an area that clearly differs from the remaining slot in its level can be recognized. This is the midamble. Since all eight code channels use the same midamble, the channels are superimposed constructively in this area, resulting in high peak levels and, therefore, high crest factors. A similar effect can be observed in the 3GPP W-CDMA FDD system when all DPCHs use the same pilot sequences (without timing offset).

If, however, the 8 code channels are assigned to different users, the time-domain signal is clearly changed.

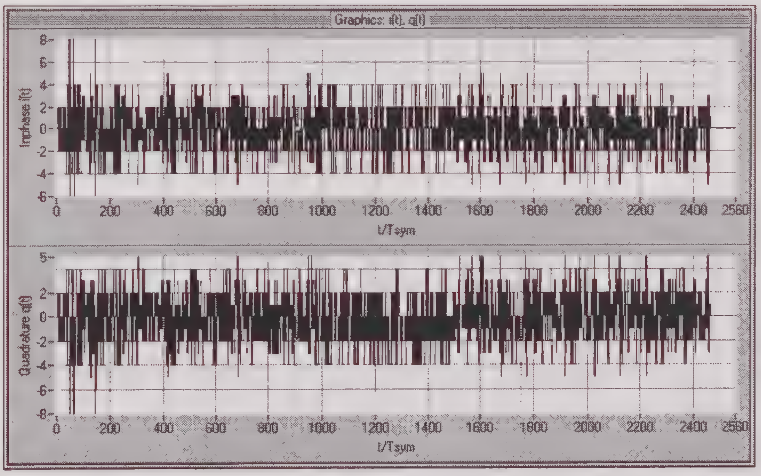


Fig. 14-32 Time-domain display of a signal comprising 8 DPCHs allocated to different users

The area of the midamble no longer differs from the remaining slot in the time-domain display. Due to the allocation of the channels to different users, different midambles with different shift values are used in the channels. Thus, these channel areas are uncorrelated and the superimposition obviously produces smaller peak levels.

Constellation of a DPCH

The constellation display of a code channel shows a diagram similar to the QPSK diagram of FDD mode.

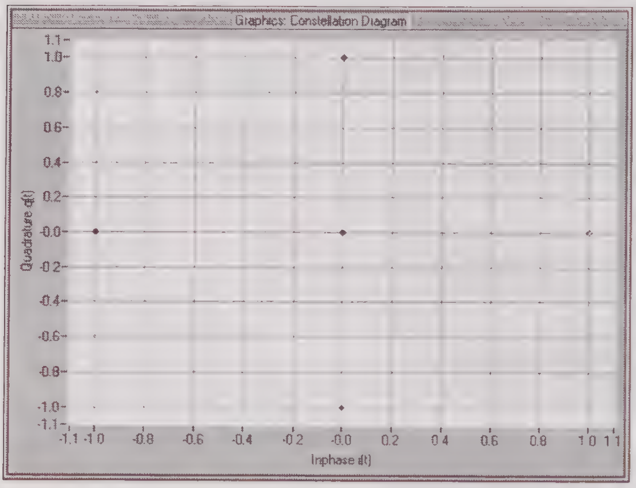


Fig. 14-33 Constellation diagram of a DPCH

Due to the guard period at the end of a slot in which the signal is blanked a fifth point is added in the origin of the constellation diagram.

This QPSK axes constellation of a DPCH is produced as a result of the modulation, spreading and scrambling procedure of the binary useful bits:

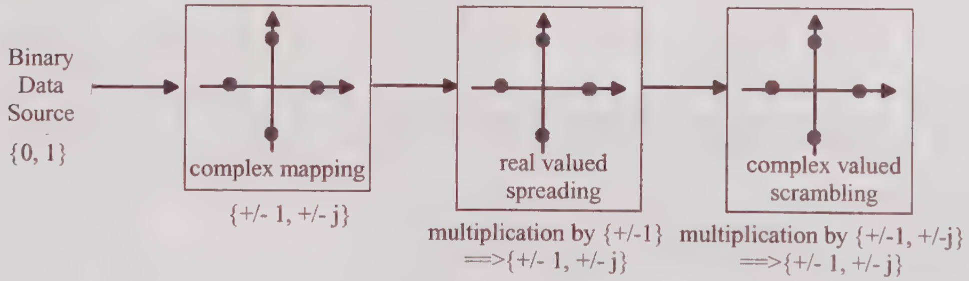


Fig. 14-34 Modulation, spreading and scrambling

In the first step, the binary useful data are mapped into the I/Q level by complex mapping of 2 data bits each. The complex data stream is spread with a real spreading code (multiplication by +/- 1). This has no effect on the constellation, the points remain positioned on the axes of the I/Q diagram. Finally, the sequence is multiplied by a complex scrambling code, the multiplication corresponding to a shift of n * 90° (+/- 1, */- j), n = 0, 1, 2, 3. Again, an axes constellation is obtained. Thus the constellation diagram of a DPCH is produced.

By activating the 3 DPCHs (with the same power) in the slot, a rhombus positioned on the vertex is obtained with a side length (number of points) of four (in general channel number +1) as with FDD. Due to the guard period, a further constellation point is added in the origin.

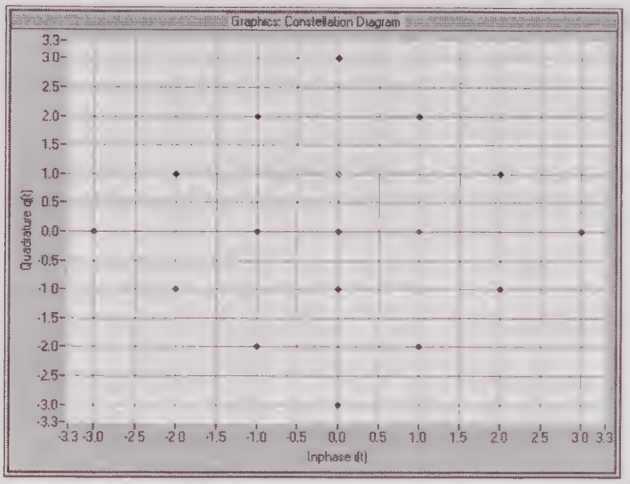


Fig. 14-35 Constellation of 3 superimposed DPCHs

14.3.2 Simulation of Complex Scenarios

The 3GPP TDD system has certain limitations to keep its operation as simple as possible:

- only one carrier frequency
- max. four cells
- no delays between the cells (simulation of delays)
- only one PRACH per slot and cell
- no mixed operation involving PRACH and dedicated mode in a slot of a cell

14.3.2.1 Generating Several Logical Cells from One Cell

To simulate several PRACH bursts in one slot, proceed as follows:

- ➢ Configure cell 1 as desired and activate the first PRACH.
- ➢ Copy cell 1 to cell 2 and modify the PRACH settings in cell 2.
- ➢ If necessary, repeat the above steps for cells 3 and 4.

Analogously, PRACH and dedicated mode can be combined in one slot.

14.3.2.2 Combination with Multi Carrier Mixed Signal

The Multi Carrier Mixed Signal system offers the possibility of versatile extensions. Several waveforms (up to 32) can be added. For a detailed description please refer to section 10.

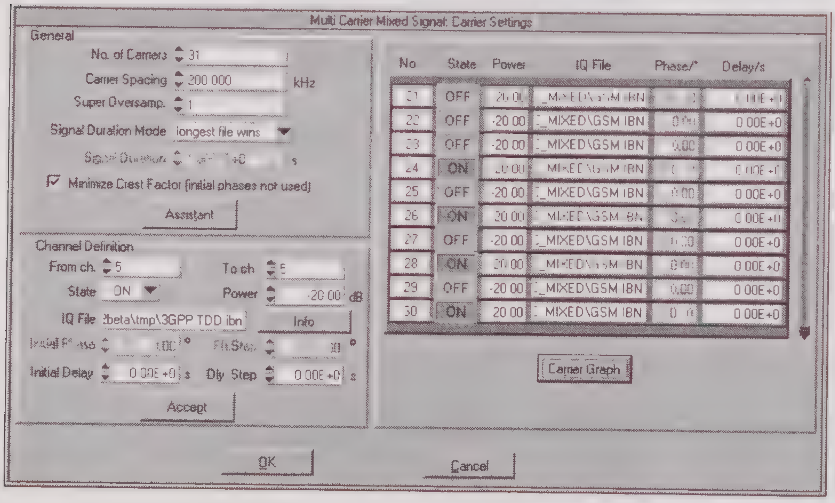
First save the waveforms in any desired system under "File/Save for Add/Multi Carrier Mixed Signal". Then go to the Multi Carrier Mixed Signal system, where you can add the saved waveforms (IBN format, i.e. full floating-point notation).

14.3.2.2.1 Simulation of Multi Carrier Scenarios

This is the main application of the Multi Carrier Mixed Signal.

- ➢ Enter channel spacing of 5 MHz (or 0.2 MHz if you wish to combine 3GPP TDD with GSM).
- ➢ Assign waveforms to the channels as desired.

Example of mixed 3GPP TDD / GSM scenario:



No. of Carriers 31
Carrier Spacing 200 000 kHz
Super Oversamp. 1
Signal Duration Mode longest file wins
☑ Minimize Crest Factor (initial phases not used)

From ch. 5
To ch 5
State ON
Power -20 00 dB
IQ File :beta\tmp\3GPP TDD ibn
Initial Delay 0 00E+0 s
Dly Step 0 00E+0 s

No	State	Power	IQ File	Phase/°	Delay/s
21	OFF	20 00	_MIXED\GSM IBN	[illegible]	0 00E+0
22	OFF	-20 00	_MIXED\GSM IBN	0 00	0 00E+0
23	OFF	-20 00	_MIXED\GSM IBN	0.00	0 00E+0
24	ON	20 00	MIXED\GSM IBN	[illegible]	0 00E+0
25	OFF	-20 00	_MIXED\GSM IBN	0 00	0 00E+0
26	ON	20 00	MIXED\GSM IBN	[illegible]	0 00E+0
27	OFF	-20 00	_MIXED\GSM IBN	0 00	0 00E+0
28	ON	20 00	_MIXED\GSM IBN	0 00	0 00E+0
29	OFF	-20 00	_MIXED\GSM IBN	0.00	0 00E+0
30	ON	20 00	MIXED\GSM IBN	0 00	0 00E+0

Fig. 14-36 Possible configuration of mixed 3GPP TDD / GSM scenario

The following spectrum is obtained for the above scenario:

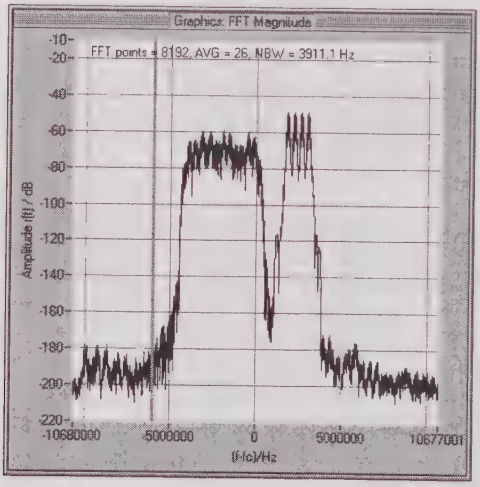


Fig. 14-37 Spectrum of mixed 3GPP TDD / GSM scenario

14.3.2.2.2 Simulation of More Than Four Cells

- Divide your scenario into subscenarios of max. four cells each.
- Configure each subscenario and store the waveforms of each scenario in a separate file ("File/Save for Add/Multi Carrier Mixed Signal").
- Make the following settings in the Multi Carrier Mixed Signal system
  - No. of Carriers = number of subscenarios,
  - Carrier Spacing = 0,
  - Super Oversampling = 1,
  - Minimize Crest Factor = Off,
  - all channel powers = 0 dB,
  - all phases = 0°,
  - all delays = 0 s.

  The subscenario signals will then be added up.

14.3.2.2.3 Simulation of Delays Between Cells

- Generate each cell separately and store the waveforms.
- Make the following settings in the Multi Carrier Mixed Signal system
  - No. of Carriers = number of subscenarios,
  - Carrier Spacing = 0,
  - Super Oversampling = 1,
  - Minimize Crest Factor = Off,
  - all channel powers = 0 dB,
  - all phases = 0°,
  - all delays to the desired values.

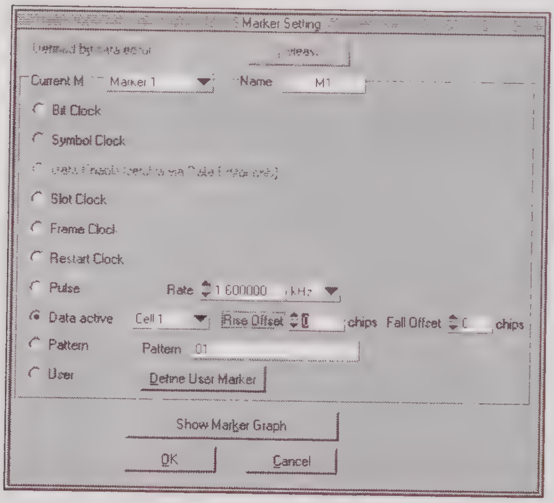
  The subscenario signals will then be added up with a time shift.
- The same method can be used to simulate delays between different slots or between the uplink code channels (of different mobiles) of a slot.

14.3.3 Increasing the Dynamic Range Between Active and Inactive Slots

The 3GPP TDD standard requires a high ON/OFF power ratio, i.e. a high dynamic range between active and inactive slots. To meet these high demands, the dynamic range in the baseband is usually not sufficient. In addition, the RF signal should be blanked in the inactive signal ranges.
This requirement is met by the combination of WinIQSIM, AMIQ and SMIQ.

Using WinIQSIM, you can conveniently configure a marker output of the AMIQ so that it marks the range of active signal components synchronously with the IQ signal. This marker signal can be used to drive the pulse modulator of the SMIQ and thus increase the dynamic range.
This method is described in greater detail in the following.

1. First define the so-called **Data active** marker in the Marker panel (AMIQ➔ Marker Settings...)

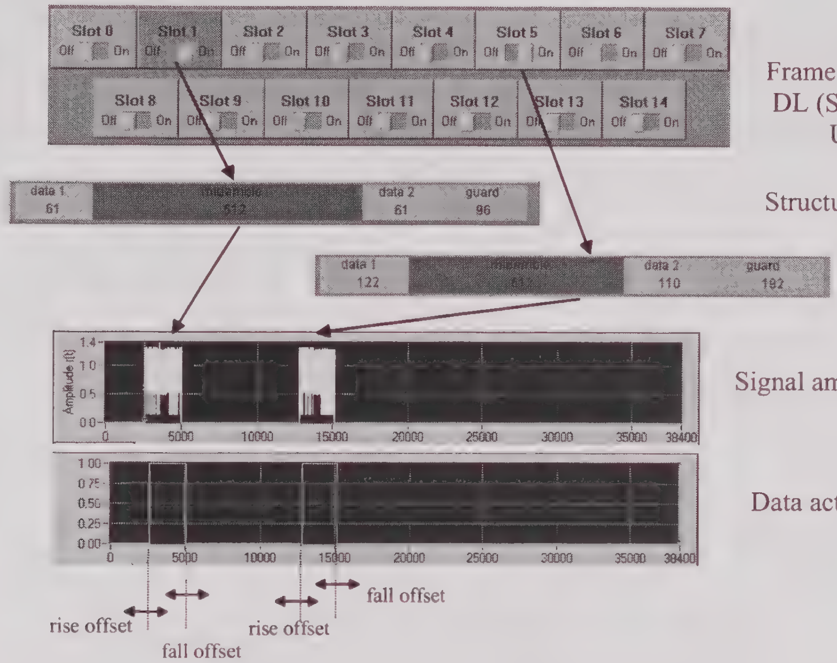

Marker Setting

Current M: Marker 1
Name: M1
○ Bit Clock
○ Symbol Clock
○ Slot Clock
○ Frame Clock
○ Restart Clock
○ Pulse Rate 1 600000 kHz
● Data active Cell 1 Rise Offset 0 chips Fall Offset 0 chips
○ Pattern Pattern 01
○ User

Fig. 14-38 Marker Setting panel 3GPP TDD

The Data active marker can only be generated for marker channel 1 of the AMIQ.

You can select for which of the 4 cells the marker is to be generated. In addition, you can shift the rising (**Rise Offset**) and falling edges (**Fall Offset**) in the marker signal independently of each other in order to match the marker signal ideally to your requirements. This function is illustrated below.



Frame Structure: one active DL (Slot 1) and one active UL Slot (Slot 5)

Structure of used bursts

Signal amplitude versus time

Data active marker versus time

Fig. 14-39 Generation of Data active marker

2. Transmit the I/Q signal to the AMIQ (AMIQ➔Transmission) and activate marker channel 1 in the AMIQ menu➔ Remote Control and BERT...
3. Connect the following input and output connectors of AMIQ and SMIQ using a BNC cable:
   - Connect I and Q output sockets of AMIQ to I and Q input sockets at the SMIQ front panel:

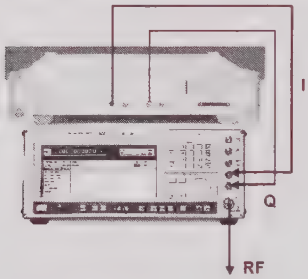


Fig. 14-40 Cabling of I/Q inputs and outputs of AMIQ and SMIQ

- Connect marker 1 output socket at the rear of the AMIQ to the pulse input socket at the rear of the SMIQ.

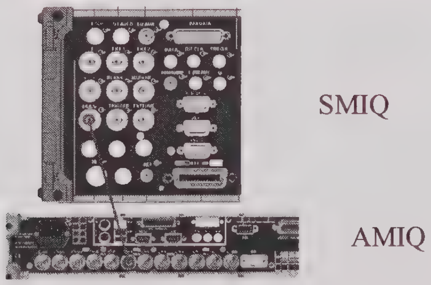
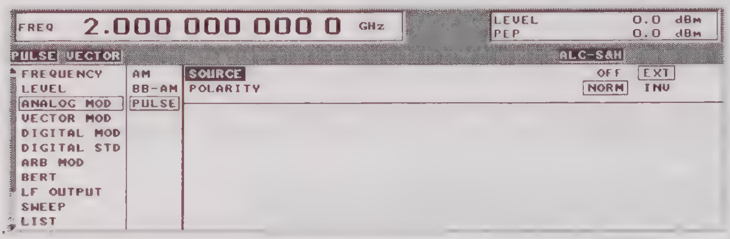


Fig. 14-41 Cabling of marker 1 of AMIQ with PULSE input of SMIQ

4. Activate vector modulation in the SMIQ and, in addition, the external pulse modulation in the ANALOG MOD➔PULSE menu.



FREQ 2.000 000 000 0 GHz
LEVEL 0.0 dBm
PEP 0.0 dBm
PULSE VECTOR
ALC-S&H
SOURCE OFF EXT
POLARITY NORM INV

Fig. 14-42 Activation of external pulse modulation in the SMIQ

5. Optimize the ON/OFF ratio by shifting the edges (rise and fall offset) in the marker panel.

Note: *After changing the offset the signal is to be transmitted to the AMIQ again.*

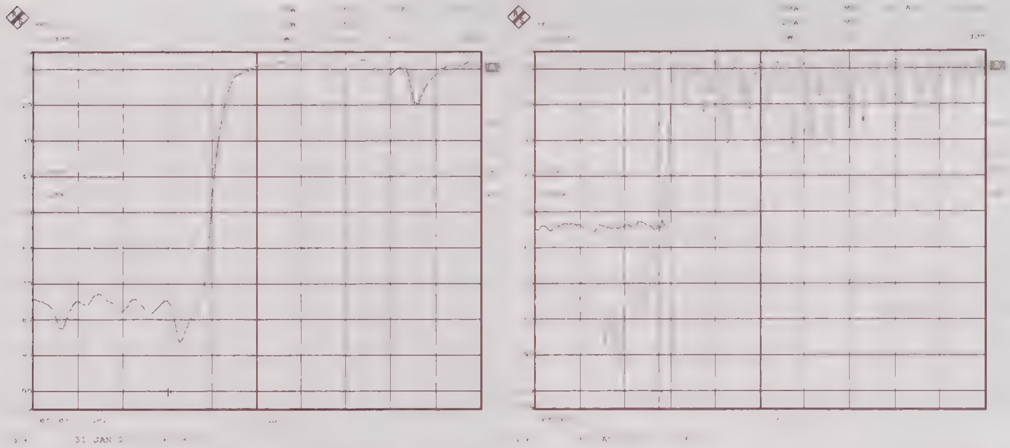


Fig. 14-43 Transition from inactive to active slot with (green curve) and without pulse modulation (yellow curve) for Rise Offset –1 (left) and –10 (right).

The curves shown above clearly indicate an increase in the dynamic range by more than 15 dB through the use of the pulse modulator.

For optimizing the ON/OFF ratio observe the following:

- The pulse modulator should not switch in the range of high edge levels. Otherwise, there will be large amplitude variations in the time domain, resulting in unwanted spurious in the spectrum. Therefore, the rise offset should lie in the range of half the negative pulse length (see Filter panel) and the fall offset in the range of half the pulse length. In this range, the I/Q signal already features very small levels.

- The pulse modulator must not switch too late either in order not to fall out of the Power Time Template required in the standard.

A compromise has to be found between these two requirements, both providing a rather clear spectrum and lying within the Power Time Template.

15 IEEE 802.11b Wireless LAN

WinIQSIM generates signals in accordance with the Wireless LAN Standard IEEE 802.11b (802.11b for short). Section 15.1 provides an initial overview of this standard. Section 15.2 describes the associated control functions. Section 15.3 provides in-depth information on generating 802.11b signals.

15.1 Description of the Wireless LAN Standard IEEE 802.11b

IEEE 802.11b is a wireless LAN standard defined by ANSI/IEEE. The standard is briefly described below. For a detailed description, refer to the relevant specifications by ANSI/IEEE (see literature), which are currently also available at **http://standards.ieee.org/getieee802/**.

Literature:

[1] ANSI/IEEE Std 802.11, 1999 Edition: Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

[2] IEEE Std 802.11b-1999 (Supplement to ANSI/IEEE Std 802.11, 1999 Edition):
Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications:
Higher-Speed Physical Layer Extension in the 2.4 GHz Band

WinIQSIM simulates 802.11b on the physical layer. The following description is therefore limited to this layer.

15.1.1 Development of the 802.11 Standard

In 1990, IEEE founded the 802.11 Working Group, which issued an initial version of the 802.11 standard in June 1997. This standard defines infrared interfaces and radio transmission in the ISM band around 2.4 GHz as transmission methods.
Radio transmission can alternatively be carried out via frequency hopping spread spectrum (FHSS) or direct sequence spread spectrum (DSSS). For a more precise distinction of these methods, refer to [1].
Originally, two data transmission modes were defined for the DSSS method.

- 1 Mbps data rate with DBPSK modulation
- 2 Mbps data rate with DQPSK modulation

Both modes spread the information data sequence with an 11-chip Barker sequence, and operate with a chip rate of 11 Mcps.

In spring 1999, the standard was expanded by the addition of an OFDM mode, 802.11a, in the frequency range of 5 GHz. A combination of the two software packages WinIQOFDM and WinIQSIM from Rohde & Schwarz can already simulate test signals to this standard. We will not go into this subject further.

Soon afterwards, in summer 1999, the DSSS mode was extended, too. This expansion to include the new data rates of 5.5 Mbps and 11 Mbps is defined in the 802.11b standard. A new modulation mode, complementary code keying (CCK), was introduced.

The 802.11b system in WinIQSIM comprises all the data rates and modulations in the DSSS mode as defined in 802.11 and the 802.11b extension. The following refers to 802.11b only.

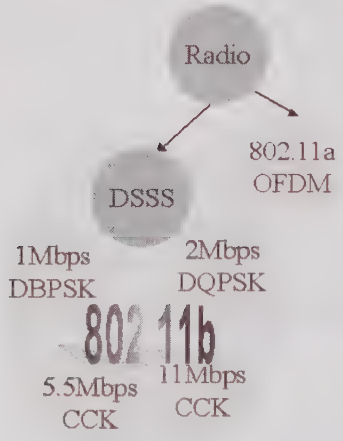


Fig. 15-1 Overview of 802.11b modulation modes

15.1.2 802.11b Packet Structure on the Physical Layer

The 802.11b wireless LAN standard is a packet-oriented method for data transfer. The data packets are transmitted and received on the same frequency in time division duplex (TDD), but without a fixed timeslot raster. An 802.11b component can only transmit or only receive packets at any particular time. The basic structure of the packets is described below.
A distinction is made between the packet type (or PPDU format) with long or short PLCP (physical layer convergence protocol).

15.1.2.1 Long PLCP PPDU Format

In 802.11b, the data packet on the physical layer is referred to as PPDU (PLCP protocol data units). A PPDU consists of three components; the PLCP preamble, the PLCP header and the PSDU (PLCP service data unit), which contains the actual information data (coming from higher layers).
The PLCP preamble and header are used for synchronization and signalling purposes, and are themselves divided into fields.

The **PLCP preamble** consists of a synchronization field and a start frame delimiter field. The standard specifies a fixed data content for both fields.

The **PLCP header** consists of the signal, service, length and CRC fields.
The signal field determines the data rate used in the PSDU field. The rates 1 Mbps, 2 Mbps, 5.5 Mbps, and 11 Mbps can be selected.
The service field also helps to differentiate the modulation modes (CCK or PBCC) used for the higher data rates of 5.5 Mbps and 11 Mbps. For details, refer to [2], section 18.2.3.4.
The length of the PSDU field is entered in µs in the Length field.
The CRC field contains a check sum of all the fields of the PLCP header.

The PLCP preamble and the PLCP header in the long PLCP PPDU format are both DBPSK-modulated and transmitted at a data rate of 1 Mbps. The data rate and the modulation of the PSDU component are defined by the signal and service fields in the PLCP header. The different types of modulation are described in section 15.1.3.

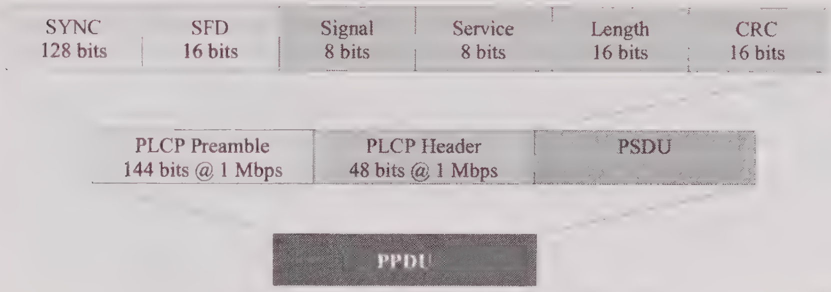


Fig. 15-2 Long PLCP PPDU format

15.1.2.2 Short PLCP PPDU Format

The basic structure of the short PLCP PPDU format is identical to that of the long PLCP PPDU format. There is no difference in the PSDU component. The PLCP preamble and header are generated in an abbreviated form. In the short preamble, the number of bits transmitted in the SYNC field is reduced from 128 to 56. In the short header, however, the number of data bits transmitted remains unchanged, but the data rate is doubled (to 2 Mbps). These measures halve the transmission periods of preamble and header in the short PLCP format, as compared to the long PLCP format.

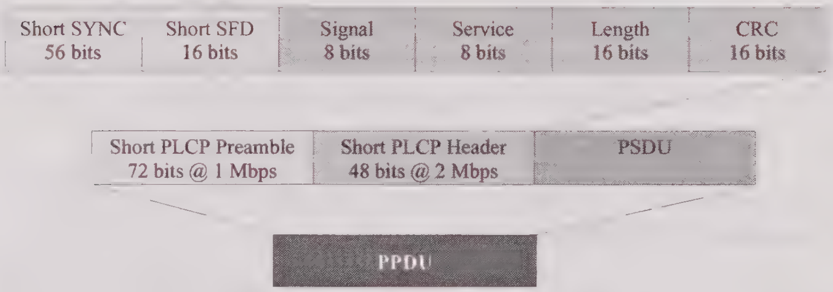


Fig. 15-3 Short PLCP PPDU format

15.1.3 Data Spreading and Modulation

WinIQSIM simulates signals in accordance with 802.11b on the physical layer. In the standard, the data link layer or, to be more precise, the MAC sublayer provides the input data for this layer The following graph illustrates the signal generation process in WinIQSIM.

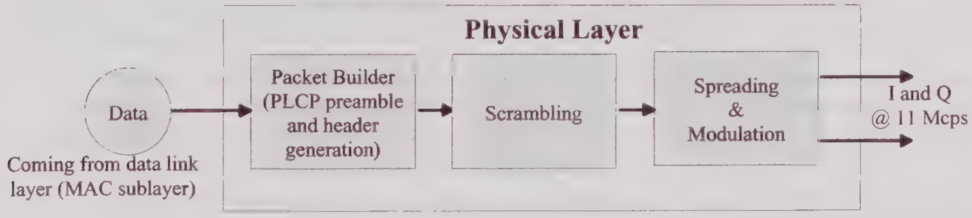

Physical Layer
Data
Coming from data link layer (MAC sublayer)
Packet Builder (PLCP preamble and header generation)
Scrambling
Spreading & Modulation
I and Q @ 11 Mcps

Fig. 15-4 Principle of signal generation

Depending on the PLCP PPDU format used, the PLCP preamble and the PLCP header are combined in the packet builder. The PSDU field of the packet is filled with the input data of the physical layer block. In the next step, all the packet data is scrambled. The actual spreading and modulation of the data signal to the resulting chip rate of 11 Mcps comes next.

However, the data rates and modulations of the individual fields of a packet can differ. The PLCP preamble always has a data rate of 1 Mbps, and is DBPSK-modulated. Besides the actual modulation, spreading to the resulting chip rate occurs.
The PLCP header is either treated exactly like the preamble (long PLCP PPDU format), or DQPSK-modulated at a data rate of 2 Mbps (short PLCP PPDU format). Four data rates (1 Mbps, 2 Mbps, 5.5 Mbps, 11 Mbps) with different modulations can be used for the data part of the packet, the PLCP service data unit (PSDU). The following table gives an overview of the different combinations of data rates, modulations and spreading/coding methods.

Packet field	**Data rate**	**Chip rate**	**Spreading/coding methods**	**Modulation**
Short PLCP preamble	1 Mbps	11 Mcps	11-chip Barker sequence	DBPSK
Long PLCP preamble	1 Mbps	11 Mcps	11-chip Barker sequence	DBPSK
Short PLCP header	2 Mbps	11 Mcps	11- chip Barker sequence	DQPSK
Long PLCP header	1 Mbps	11 Mcps	11-chip Barker sequence	DBPSK
PSDU	1 Mbps (long PPDU)	11 Mcps	11- chip Barker sequence	DBPSK
	2 Mbps	11 Mcps	11-chip Barker sequence	DQPSK
	5.5 Mbps	11 Mcps	CCK	DQPSK
	11 Mbps	11 Mcps	CCK	DQPSK
	5.5 Mbps	11 Mcps	PBCC	BPSK
	11 Mbps	11 Mcps	PBCC	QPSK

The individual combinations of spreading, coding and modulation are described below.

15.1.3.1 1 Mbps Data Rate with DBPSK Modulation

At a data rate of 1 Mbps, the already scrambled data stream is DBPSK-modulated according to the table below. The resulting symbol sequence is then spread using the 11-chip Barker sequence.

Bit input	**Phase change (+jω)**
0	0
1	π

15.1.3.2 2 Mbps Data Rate with DQPSK Modulation

At a data rate of 2 Mbps, the already scrambled data stream is DQPSK-modulated according to the table below. The resulting symbol sequence is then spread using the 11-chip Barker sequence.

Dibit pattern (d0,d1) (d0 is first in time)	**Phase change (+jω)**
00	0
01	$\pi/2$
11	π
10	$3\pi/2$ ($-\pi/2$)

15.1.3.3 5.5 Mbps Data Rate with CCK Modulation

The standard specifies CCK modulation (complementary code keying) for a data rate of 5.5 Mbps. To this end, in each modulation step, four successive bits (d_0 to d_3) are taken from the data stream which is already scrambled. The phases $\varphi_1, \varphi_2, \varphi_3, \varphi_4$ are determined by these four bits. φ_1 is determined by the data bits d_0 and d_1 according to the following table, which specifies different phases for even and odd modulation steps:

Dibit pattern (d0, d1) (d0 is first in time)	**Even symbols phase change (+jω)**	**Odd symbols phase change (+jω)**
00	0	π
01	π/2	3π/2 (−π/2)
11	π	0
10	3π/2 (−π/2)	π/2

The phase φ_1 must be interpreted relative to the phase of the previous symbol.

The other three phases are determined as follows:

$$\varphi_2 = (d_2 \cdot \pi) + \pi/2$$

$$\varphi_3 = 0$$

$$\varphi_4 = d_3 \cdot \pi$$

By means of these four phases, the CCK code word can now be determined; it is:

$$c = \{e^{j(\varphi_1+\varphi_2+\varphi_3+\varphi_4)}, e^{j(\varphi_1+\varphi_3+\varphi_4)}, e^{j(\varphi_1+\varphi_2+\varphi_4)},$$
$$-e^{j(\varphi_1+\varphi_4)}, e^{j(\varphi_1+\varphi_2+\varphi_3)}, e^{j(\varphi_1+\varphi_3)}, -e^{j(\varphi_1+\varphi_2)}, e^{j\varphi_1}\}$$

Example:
(d_0 to d_3) = (0110), the phase of the last symbol is 0, the current modulation step is even:

$$\varphi_1 = \pi/2$$

$$\varphi_2 = (1 \cdot \pi) + \pi/2 = 3\pi/2$$

$$\varphi_3 = 0$$

$$\varphi_4 = 0 \cdot \pi = 0$$

The CCK code word is consequently:

$$c = \left(e^{j(\pi/2+3\pi/2+0+0)}, e^{j(\pi/2+3\pi/2+0)}, e^{j(\pi/2+3\pi/2+0)}, -e^{j(\pi/2+0)}, e^{j(\pi/2+3\pi/2+0)}, e^{j(\pi/2+0)}, -e^{j(\pi/2+3\pi/2)}, e^{j\pi/2},\right)$$

$$c = \left(e^{j0}, e^{j0}, e^{j0}, -e^{j\pi/2}, e^{j0}, e^{j\pi/2}, -e^{j0}, e^{j\pi/2},\right) = (1,1,1,-j,1,j,1,j,)$$

The four data bits (d_0 to d_3) thus become the eight complex output chips (c_0 to c_7).

15.1.3.4 11 Mbps Data Rate with CCK Modulation

The standard also specifies CCK modulation (complementary code keying) for a data rate of 11 Mbps. The modulation is basically the same as described for the 5.5 Mbps data rate. In each modulation step, eight successive bits (d_0 to d_7) are taken from the data stream, which is already scrambled. The phases $\varphi_1, \varphi_2, \varphi_3, \varphi_4$ are determined by these eight bits.

φ_1 is determined by the data bits d_0 and d_1 according to the following table, which specifies different phases for even and odd modulation steps:

Dibit pattern (d0, d1) (d0 is first in time)	Even symbols phase change (+jω)	Odd symbols phase change (+jω)
00	0	π
01	π/2	3π/2 (−π/2)
11	π	0
10	3π/2 (−π/2)	π/2

The phase φ_1 must be interpreted relative to the phase of the previous symbol.

φ_2 is determined by the data bits d_2, d_3, φ_3 from d_4, d_5 and φ_2 from d_6, d_7 according to the following table:

Dibit pattern [di, d(i+1)] (di is first in time)	Phase
00	0
01	π/2
10	π
11	3π/2 (−π/2)

15.1.3.5 5.5 Mbps and 11 Mbps Data Rates with PBCC Modulation

Packet binary convolutional coding (PBCC) can optionally be used instead of CCK modulation for the 5.5 Mbps and 11 Mbps data rates. For details, refer to [2]. The following illustration provides a schematic overview of this method. For details, refer to the standard.

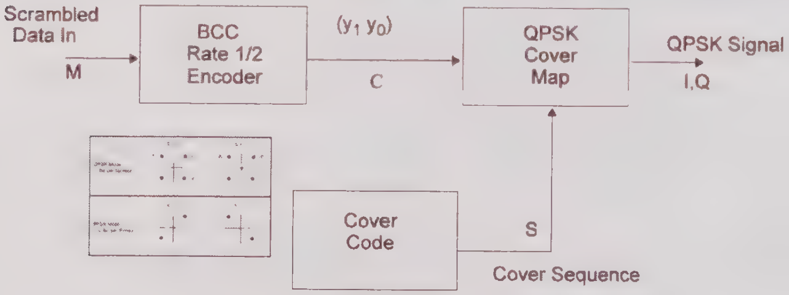
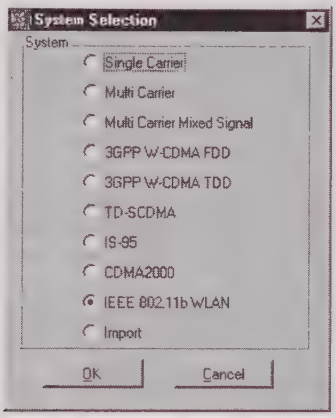


Fig. 15-5 Principle of PBCC modulation

15.2 Generation of 802.11b Signals with WinIQSIM

To generate an 802.11b signal, the IEEE 802.11b WLAN system must first be selected.


System Selection

System

○ Single Carrier
○ Multi Carrier
○ Multi Carrier Mixed Signal
○ 3GPP W-CDMA FDD
○ 3GPP W-CDMA TDD
○ TD-SCDMA
○ IS-95
○ CDMA2000
● IEEE 802.11b WLAN
○ Import

Fig 15-6 802.11b System Selection

System Selection is accessible via the File/New... or System! menu.
The differences between the two methods are described in sections 5.22.1 and 5.23.

The 802.11b block diagram is based on that of the single-carrier system. Only block modulation is replaced by the IEEE 802.11b configuration block.

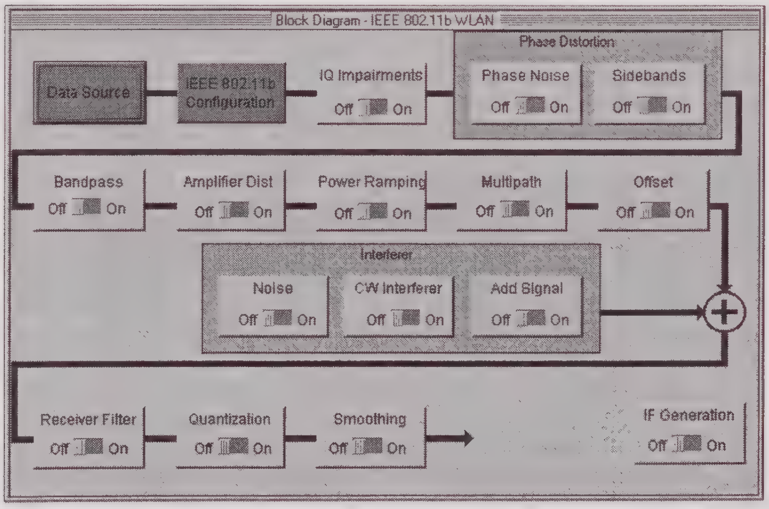


Fig. 15-7 Block Diagram of the 802.11b system

The Data Source block corresponds to that of the single-carrier system. For a description, refer to section 5.6.

15.2.1 Status Line

The most important parameters of the 802.11b system are displayed in the status line below the toolbar of the main panel. The set parameters can thus be seen at a glance.

The status line contains symbols for the different parameters; below the symbols, the current parameter values are indicated. The figure below shows the status line of the 802.11b system with the parameters assigned to the symbols.

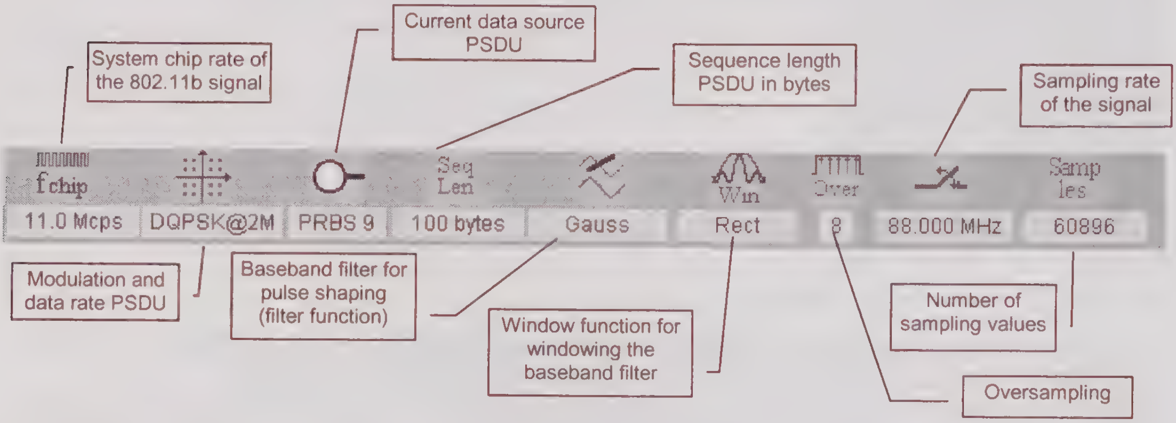

System chip rate of the 802.11b signal
Current data source PSDU
Sequence length PSDU in bytes
Sampling rate of the signal
fchip
Seq Len
Win
Over
Samp les
11.0 Mcps
DQPSK@2M
PRBS 9
100 bytes
Gauss
Rect
8
88.000 MHz
60896
Modulation and data rate PSDU
Baseband filter for pulse shaping (filter function)
Window function for windowing the baseband filter
Number of sampling values
Oversampling

Fig. 15-8 Status line of the 802.11b system

15.2.2 IEEE 802.11b Configuration Panel

All the major control elements of the 802.11b system are displayed in this window.
802.11b signals can be generated in two different modes. The **Framed Mode** is the standard operating mode, as in the real system. Data packets are generated, with the frame structure defined in the standard. In addition, the **Unframed Mode** is available. In this mode, a non-packet-oriented signal is generated without a frame structure, but with the modulations and data rates defined in 802.11b. This mode is suitable for simple initial tests which focus only on the modulation and spectrum of the test signal.
The operation of these two modes is described in detail below.

Chip rate variation:
This parameter enables modification of the output chip rate (i.e. the rate of the spread symbols, which is used for signal output by the AMIQ or the SMIQ) relative to the standard chip rate of 11 Mcps. The standard value is 11 Mcps; resetting is possible at any time by pressing the **Set to standard** button.

15.2.2.1 Framed Mode

The current simulation mode is visualized in the upper part of the panel. In the framed mode, the following display is output:

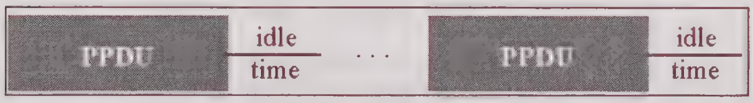


Fig. 15-9 Simulation mode display

The framed mode allows the configuration of a signal that generates a series of packets (PLCP protocol data units, in short PPDUs), which are separated by idle time. The information data in the consecutive packets continues, i.e. it is not repeated in the packets. Both the duration of idle time and the number of packets to be transmitted can be configured with the following parameters.

Idle time (based on standard chip rate):
The waiting period between consecutive packets (PPDUs) can be set in this field. Idle time is given in µs; the packets can also be joined to each other directly with idle time 0. Please note that the idle time refers to the chip rate of 11 Mcps as defined in the 802.11b standard. Only at this chip rate does the idle period correspond exactly to the time set. If the chip rate is doubled, for instance, the real idle time is halved.

Number of packets:
The number of packets to be generated is entered here. The minimum packet number is 1; the maximum number of packets is determined by the memory capacity of the AMIQ or the ARB option (B60) in the SMIQ. The total length of a packet in samples depends on the packet format, the data length, the idle time and the oversampling. The number of packets currently possible can then be determined, depending on the AMIQ model, or the SMIQ B60.

Example: Framed mode, idle time = 500 µs, long PLCP format, data rate 11 Mbps, CCK modulation, PSDU data length 1000 Bytes, oversampling 4
With these parameters, the packet length, including idle time, is 62448 samples. The current total length is also displayed in the WinIQSIM status line. This packet length results in the following maximum packet numbers:

Instrument	Maximum packet number for above example
AMIQ03	64
AMIQ04	256
SMIQB60 (oversampling 2 is sufficient, since the SMIQ ARB internally oversamples the signal into hardware)	16

PLCP P+H format:
The PLCP preamble and PLCP header formats can be selected in this field. The long PLCP and short PLCP formats are both defined in the standard (refer to 15.1.2). Depending on the format selected, the structure, modulation and data rate of the PLCP preamble and header are modified. The format currently set is shown in the graphic display directly above the parameter format in the panel.

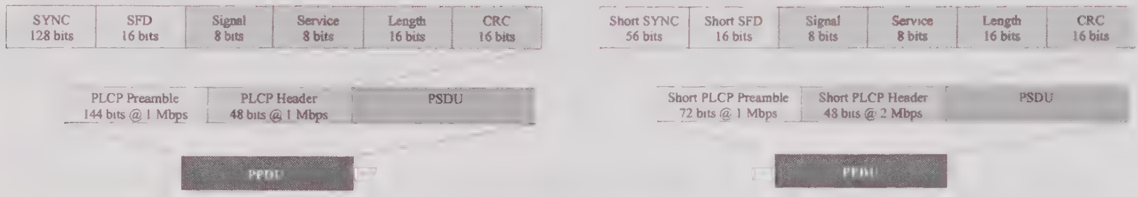

- Long PLCP format
- Short PLCP format

Fig 15-10 PLCP format display

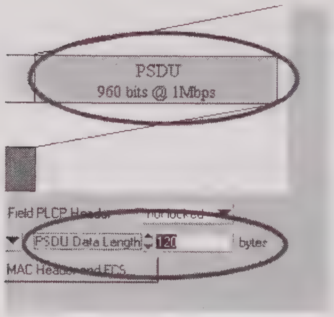
Locked clock bit in PLCP header service field:
Via this flag (bit), the 802.11b transmitter indicates whether transmission frequency and symbol rate have been derived from the same oscillator. If this is the case (locked), the bit is set to 1, otherwise (not locked) to 0.
Note: In the original 802.11 standard, this bit was fixed at 0. To simulate the appropriate signals, the parameter must therefore be set to not locked.

PSDU bit rate:
The data rate of the PSDU field is determined here. The data rates available are 1 Mbps, 2 Mbps, 5.5 Mbps, and 11 Mbps. The 1 Mbps data rate is only available if the long PLCP format has been selected. The selection of the data rate also determines the possible modulation modes. The following table shows the correlation between data rate and modulation:

Data rate	Possible modulation mode
1 Mbps	DBPSK
2 Mbps	DQPSK
5.5 Mbps	CCK or PBCC
11 Mbps	CCK or PBCC

PSDU modulation:
The PDSU modulation mode can be selected here. The possible modulations depend on the data rate (see above table). DBPSK, DQPSK, CCK and PBCC are available.

PSDU data length:
This enables selection of the information data field length of the packet to be transmitted in bytes.
The values range from 0 bytes to 2312 bytes (maximum frame body length in the MAC layer). The length in bits, resulting from the currently set PSDU data length in bytes, is automatically output in the PPDU graphics display.



PSDU
960 bits @ 1Mbps

PSDU Data Length 120 bytes

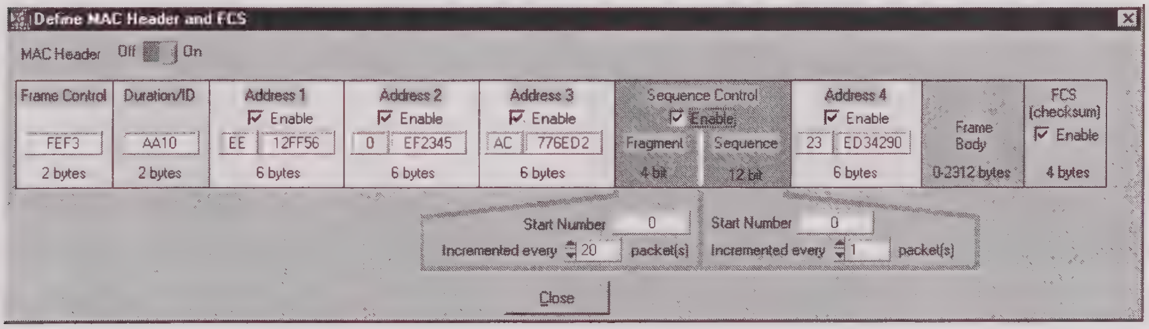
Fig 15-11 Display of the PSDU length in bits and bytes

Data source PSDU:
As with the single-carrier system, the data source, from which the information data is taken for the PSDU, can be set in the data source block of the block diagram For detailed information on the data source panel, refer to section 5.6.

Scrambling mode:
Selects whether or not to scramble the data of the packet. Some tests in [1] require a test signal without scrambling (e.g. for the RF carrier suppression measurement).

15.2.2.1.1 Define MAC Header and FCS

In the real IEEE 802.11b system, a MAC (medium access control) header is transmitted in the PSDU prior to the actual data; the header contains control information from higher layers. In addition, it is possible to protect the PSDU by means of a check sum. These two functions can be controlled in the Define MAC Header and FCS panel.



Define MAC Header and FCS

MAC Header Off ▨ On

Frame Control	Duration/ID	Address 1	Address 2	Address 3	Sequence Control	Address 4	Frame Body	FCS (checksum)
		☑ Enable	☑ Enable	☑ Enable	☑ Enable	☑ Enable		☑ Enable
FEF3	AA10	EE 12FF56	0 EF2345	AC 776ED2	Fragment Sequence	23 ED34290		
2 bytes	2 bytes	6 bytes	6 bytes	6 bytes	4 bit 12 bit	6 bytes	0-2312 bytes	4 bytes

Fragment: Start Number 0, Incremented every 20 packet(s)

Sequence: Start Number 0, Incremented every 1 packet(s)

Fig. 15-12 Define MAC Header and FCS panel

MAC header state:
Selects whether or not the PSDU is to contain a MAC header.
If the state is on, all the MAC header fields are released for operation, and you can edit them.

A brief description of the individual fields of the MAC header is given below; for details, refer to [2], section 7.1 MAC Frame Formats.
All MAC field values are entered in hexadecimal form.

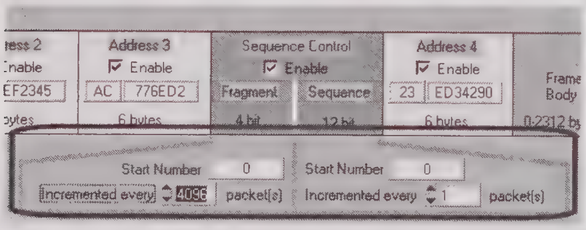
Frame control:
The Frame Control field has a length of 2 bytes (16 bit) and is used to determine the protocol version, the frame type and its function.

Duration/ID:
Depending on the frame type, the 2-byte Duration/ID field is used to transmit the association identity of the station which transmits the frame, or to indicate the duration assigned to the frame type.

Addresses 1 to 4:
There is a maximum total of four address fields in the MAC header, but not all of them must be available. Each of the four address fields can therefore be activated or deactivated. The fields are used to transmit the Basic Service Set Identifiers, the Destination Address, the Source Address, the Receiver Address and the Transmitter Address. Each address has a length of 6 bytes (48 bit). The addresses can be divided into the two most significant bytes (16 MSBs) and the four least significant bytes (32 LSBs), and then entered in hexadecimal form in any address field.

Sequence control:
The Sequence Control field has a length of 2 bytes and is subdivided in two fields, the fragment number (4 bit) and the sequence number (12 bit). A long information data stream to be transmitted is first divided into fragments, and these fragments are divided, in turn, into sequences. The Sequence and Fragment number fields are used to number the individual partial packets of the information data stream which are transmitted. Thus, the PSDUs are basically assigned consecutive numbers. This enables the receiver to sequence the data packets correctly, to check if a packet was transmitted again (if it was impaired, for example) and to detect if packets are missing.
If the receiver detects an error-free packet and does not request repeated transmission, the sequence number field is incremented by 1 for each packet (at a count of max. 4095, the field is reset to 0). The Fragment number field is incremented by 1 if the number of sequences (or packets) a fragment contains has been reached. The count at which the transmission is to start (usually 0), and the number of packets necessary to increment the associated counter can now be defined for both fields. This is done via the respective parameters, **Start Number** and **Increment every ... packet(s)**.

Example:
You want to simulate the error-free transmission of 50 packets (only one transmission per packet). The sequence number should continue to increment by 1 with each packet. Due to the small number of packets, the fragment counter can remain at 0. Set the following values:



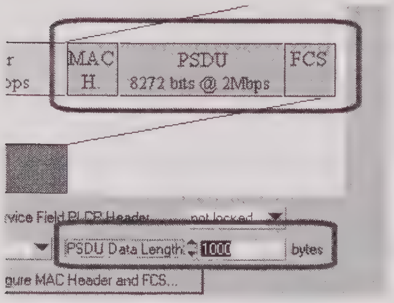
Start Number 0
Incremented every 4096 packet(s)
Start Number 0
Incremented every 1 packet(s)

Fig 15-13 Example of setting the sequence control

To simulate the reception of faulty packets, or to test the receiver's response if the same packet arrives several times, set the number of packets necessary to increment the sequence number (e.g. to 2). Each packet will then be automatically transmitted twice (containing identical data)

FCS (check sum):
The standard defines a 32-bit (4-byte) check sum to protect the MAC header and the actual information data (frame body). It is possible to select whether or not to calculate and attach this check sum. This check sum is also referred to as the frame check sequence (FCS).

To see at a glance in the IEEE 802.11b configuration panel whether the MAC header and the FCS are active, the frame graph is adapted according to the current setting.



PLCP Header: not locked

PSDU Data Length: 1000 bytes

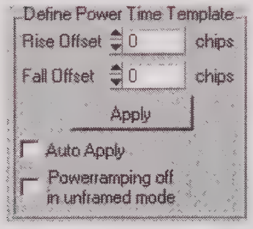
Fig 15-14 Frame display with active MAC header and FCS

The frame display shows whether the MAC header and/or the FCS are active. Additionally, the total length of the PSDU, consisting of MAC header, frame body and FCS, is indicated.
In this example, the frame body has a length of 8000 bits (PSDU data length of 1000 bytes multiplied by 8 bits/bytes), and the MAC header and the FCS together have a length of 272 bits.

15.2.2.1.2 Define Power Time Template

With 802.11b, the data packets are transmitted as bursts. Power is transmitted only if a packet is transmitted; when the packet transmission starts, power rises to the transmission level of the packet, remaining constant during transmission, and dropping again at the end; power transmission restarts with the next packet. The power ramps at the beginning and the end of a packet are defined in [2], section 18.4.7.6.

The Define Power Time Template area and the Power Ramping Panel (see section 5.13) in the WinIQSIM block diagram can be used to influence the positions and characteristics of these ramps.


Define Power Time Template

Rise Offset: 0 chips

Fall Offset: 0 chips

Apply

☐ Auto Apply

☐ Powerramping off in unframed mode

Fig. 15-15 Definition of the power time template

Rise Offset:
This parameter is used to shift the start position of the power-on ramp of a packet with regard to the start of the packet. The shifting is performed with a resolution of 1 chip.

Fall Offset:
This parameter is used to shift the start position of the power-off ramp of a packet with regard to the end of the packet. The shifting is performed with a resolution of 1 chip.

If you click on the **Apply** button, the start and end of the data packets, as defined in the current configuration of the 802.11b signal, are entered as ramp positions in the table in the Power Ramping panel, with the Rise Offset and Fall Offset being taken into consideration. If you activate the **Auto Apply** option, the Power Ramping panel is automatically adapted to all modifications of the 802.11b signal (such as packet length, idle time, and number of packets).

The **Power ramping off in unframed mode** option is used to automatically switch off the power ramping if you switch to the Unframed mode. Otherwise, the last settings made in the Framed mode (or directly in the Power Ramping panel) apply to the Unframed mode.

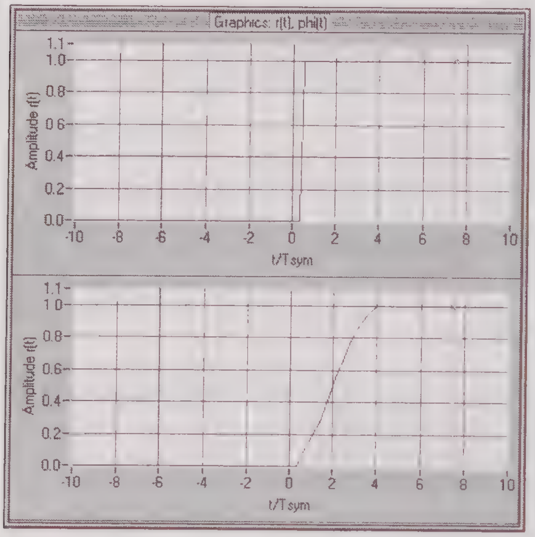
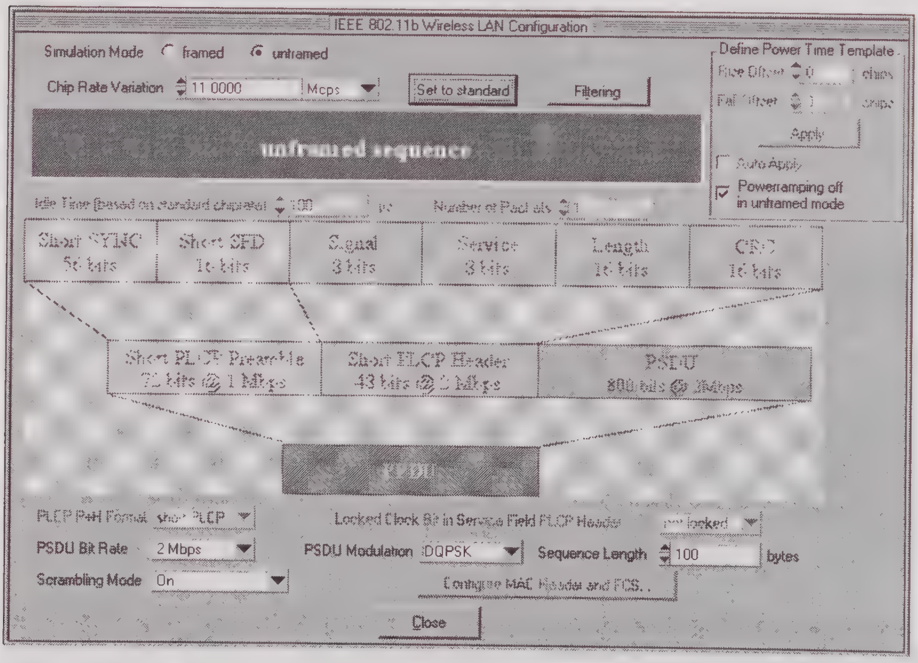


Fig. 15-16 Comparison of power characteristics at the packet start with and without power ramping

The above illustration shows the power characteristics at the packet start without additional power ramping (top), and with power ramping with $\cos^2$ ramp function and 4 chip ramp time (bottom). This function enables the packet edges to be precisely adapted to meet your requirements.

15.2.2.2 Unframed Mode

In the Unframed mode, a non-packet-oriented signal is generated without a frame structure, but with the modulations and data rates defined in 802.11b. This mode is suitable for simple initial tests which focus only on the modulation and spectrum of the test signal.
Operation is basically identical to that in the Framed Mode; however, only a subset of the setting parameters is available. In the Unframed Mode, the 802.11b configuration panel appears as follows:


IEEE 802.11b Wireless LAN Configuration

Simulation Mode ○ framed ● untramed

Chip Rate Variation 11 0000 Mcps

☑ Powerramping off in unframed mode

PSDU Bit Rate 2 Mbps

PSDU Modulation DQPSK

Sequence Length 100 bytes

Scrambling Mode On

Fig. 15-17 802.11b configuration panel in the unframed mode

The signal can be configured via the **PSDU bit rate** and **PSDU modulation** parameters, just as in the Framed mode. However, a preamble or header is not generated; only a continuous PSDU block is generated, the length of which can be varied by using the **Sequence Length** parameter. The restriction of the maximum PSDU block length to 2312 bytes in the Framed mode, as defined in the standard, has been revoked.
Moreover, the data stream can be scrambled prior to the modulation (**Scrambling Mode** parameter).

Data source:
As with the single-carrier system, the data source, from which the information data for the signal is taken, can be set in the data source block of the block diagram. For detailed information on the data source panel, refer to section 5.6.

15.2.2.3 Filtering

The generated raw chips are subjected to baseband filtering, which is implemented in the same way as in the single-carrier system.
The standard does not specify a particular baseband filter; the choice of filter lies with the manufacturer of 802.11b components. However, the standard (see [2], 18.4.7.3) does define the transmit spectrum mask that must be complied with.

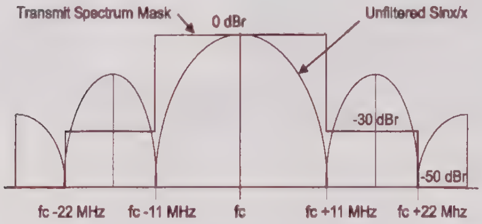
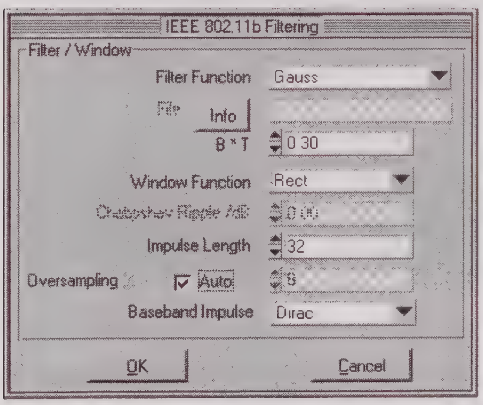


Fig. 15-18 Transmit spectrum mask

To comply with these spectral requirements in the standard, we recommend using a Gaussian filter with BT = 0.3 as baseband filter. The filter panel below shows this setting.


IEEE 802.11b Filtering

Filter / Window

Filter Function: Gauss

B * T: 0 30

Window Function: Rect

Chebyshev Ripple /dB: [illegible]

Impulse Length: 32

Oversampling: ☑ Auto [illegible]

Baseband Impulse: Dirac

Fig. 15-19 IEEE 802.11b filtering

The individual parameters are described in section 5.8, Modulation Settings Panel.

The following graph shows the spectrum of an 802.11b signal with rectangular filter in the baseband (sin x / x, grey trace), the transmit spectrum mask (red limiting lines) and the signal filtered with a Gaussian filter with BT = 0.3 (blue trace).

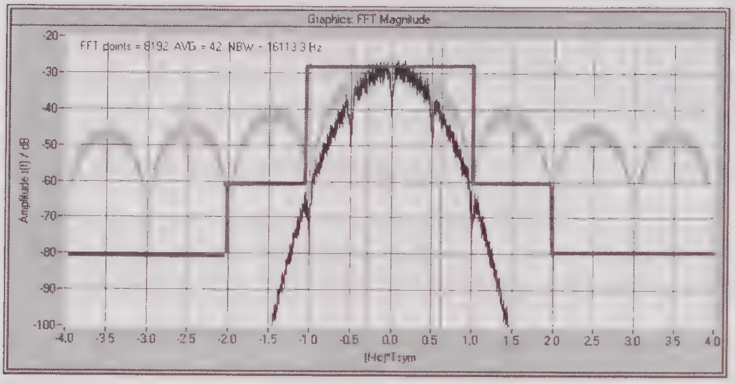


Fig. 15-20 IEEE 802.11b signal with different baseband filters

The graphic display clearly shows that the signal filtered with a Gaussian filter in the baseband is within the transmit spectrum mask defined by the standard.

15.3 Further Information on the Generation of 802.11b Signals

15.3.1 802.11b Signal in Time and Frequency Domain

15.3.1.1 Time Domain

The different modulations which are present in the preamble, header and PSDU can be at least partially recognized in the time domain. To this end, I and Q of a signal are displayed versus time in the Framed Mode with long PLCP format and a PSDU bit rate of 2 Mbps.

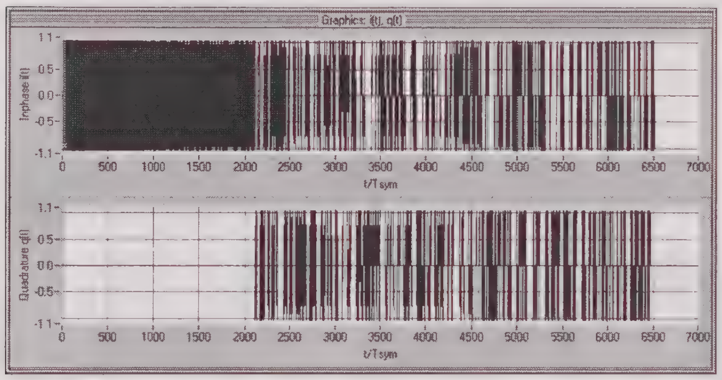


Fig. 15-21 I(t) and Q(t) of an 802.11b signal with long PLCP format

The above illustration shows that only an I component is present in the first part of the time domain signal, Q is 0. These are the PLCP preample and the PLCP header, which are both DBPSK-modulated. They are followed by the DQPSK-modulated PSDU (2 Mbps bit rate).
Zooming in the transition point between the PLCP header and the PSDU visualizes further details.

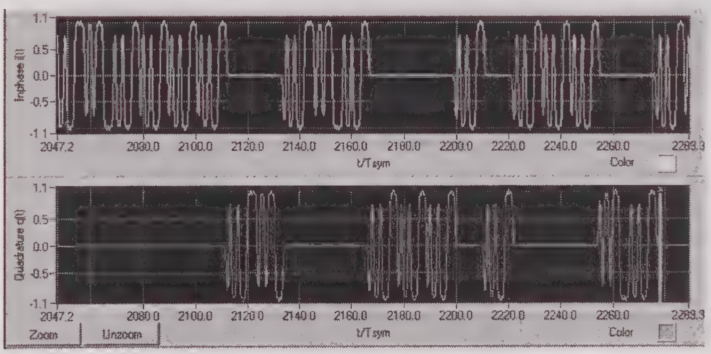


Fig. 15-22 Transition from PLCP header to PSDU with 2 Mbps DQPSK

Besides the transition from the PLCP preamble to the PSDU and the associated modulation change, this signal section reveals a special feature of the DQPSK modulation of the PSDU. In blocks of 11 chips each (length of the Barker spread sequence) or a multiple thereof, only the I or the Q component of the signal is active. For each data symbol (2 data bits), the Barker sequence shifted by $n \cdot \pi / 2$ is output. n is here between 0 and 3, and depends both on the data bits and whether the symbol interval is even or odd.

If you use a bit rate of, for instance, 11 Mbps with CCK modulation instead of the PDSU bit rate of 2 Mbps, the PSDU signal has a different characteristic.

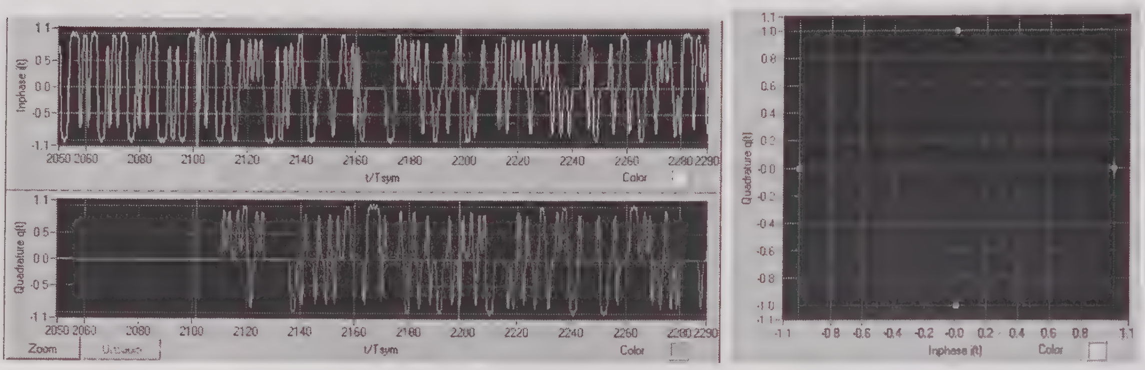


Fig. 15-23 Transition from PLCP header to PSDU with 11 Mbps CCK

15.3.1.2 Frequency Domain

The spectral behaviour of the 802.11b signal is influenced mainly by the baseband filter used. If a rectangular filter is used, the spectrum shows the typical sin x / x characteristic. If a Gaussian filter with BT = 0.3 is used (as explained earlier), the transmit spectrum mask defined in the standard is complied with.

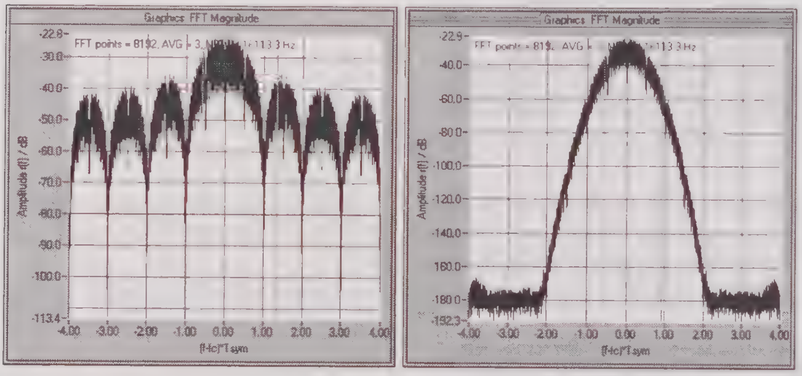


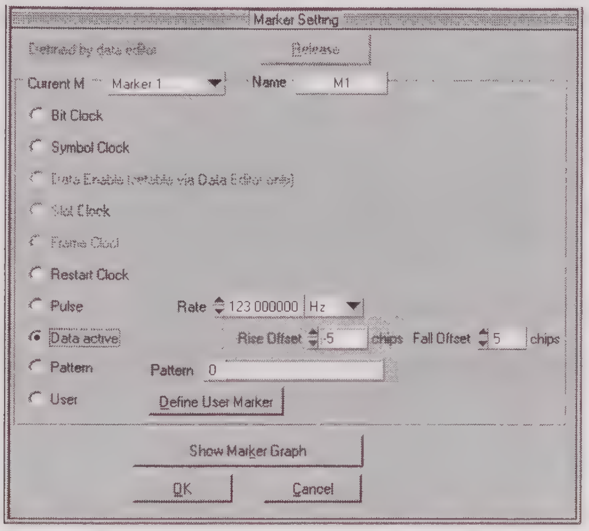
Fig. 15-25 Spectrum of an 802.11b signal with rectangular filter (left) and Gaussian filter (right)

15.3.2 Increase in the Dynamic Range between Packet and Idle Range

The dynamic range in the baseband is usually not sufficient to achieve a high ON/OFF power ratio, i.e. high dynamic range between active and inactive signal components (packet and idle range). Additionally, the RF signal should be switched off in the inactive signal spectrum.
The combination of WinIQSIM, AMIQ and SMIQ fully complies with this requirement.

WinIQSIM allows easy configuration of an AMIQ marker output, so that the latter marks the spectrum of active signal components synchronously to the I/Q signal. This marker signal can be used to control the pulse modulator of the SMIQ, and thus to increase the dynamic range.
This method is detailed below.

1. First define the Data active marker in the Marker Panel (AMIQ→ Marker Setting...).



Current M Marker 1
Name M1
● Data active
Rate 123 000000 Hz
Rise Offset -5 chips Fall Offset 5 chips
Pattern 0

Fig. 15-26 3GPP TDD Marker Setting panel

The Data active marker can now be generated for marker channel 1 of the AMIQ.

You can shift the rising (**Rise Offset**) and falling (**Fall Offset**) edges in the marker signal independently of each other, to optimally adapt the signal to your requirements. The following graph illustrates this function.

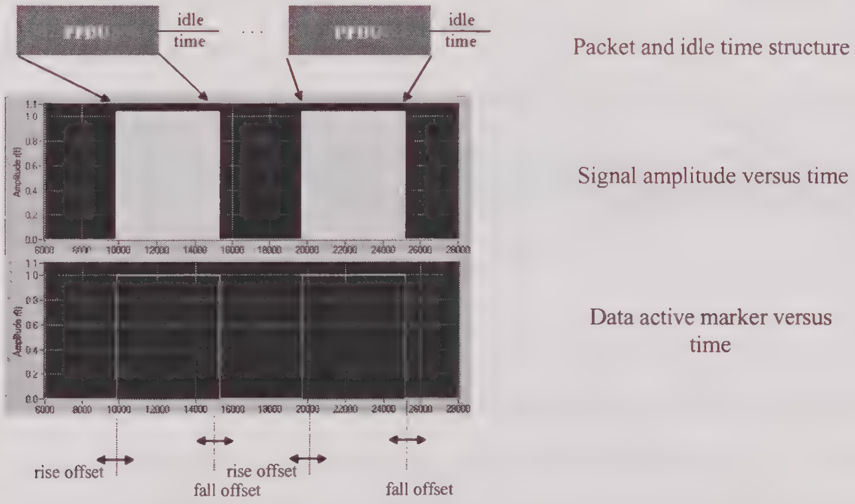


Fig. 15-27 Generation of the data active marker

2. Transmit the I/Q signal to the AMIQ (AMIQ➔Transmission) and activate marker channel 1 in the AMIQ ➔ Remote Control and BERT... menu.
3. Connect the following input and output connectors of the AMIQ and SMIQ with BNC cables:
    - the AMIQ I/Q output connectors with the I/Q input connectors on the SMIQ front panel:

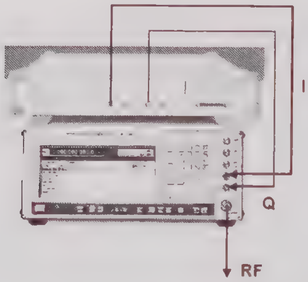


Fig. 15-28 Cabling of the I/Q inputs and outputs of the AMIQ and SMIQ

- Marker 1 output connector at the rear of the AMIQ with the pulse input connector at the rear of the SMIQ.

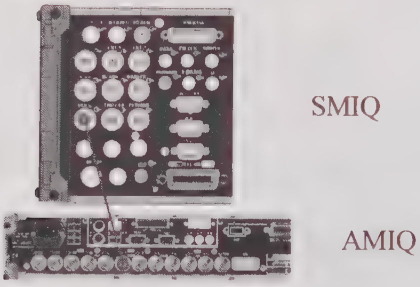


Fig. 15-29 Cabling of the AMIQ marker 1 with SMIQ PULSE input

4. Activate vector modulation in the SMIQ and, in addition, the external pulse modulation in the ANALOG MOD➔PULSE menu.

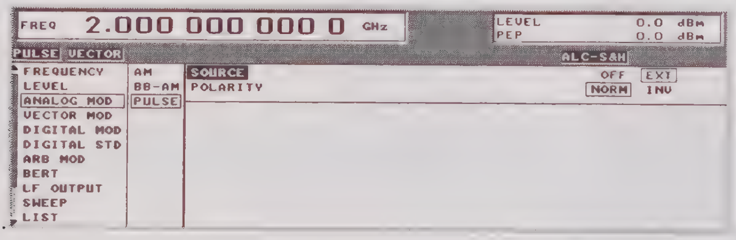

FREQ 2.000 000 000 0 GHz
LEVEL 0.0 dBm
PEP 0.0 dBm
SOURCE OFF EXT
POLARITY NORM INV

Fig. 15-30 Activating external pulse modulation in the SMIQ

5. Optimize the ON/OFF ratio by shifting the edges (Rise and Fall Offset) in the marker panel.

Note: *After an offset modification, the signal must again be transmitted to the AMIQ.*

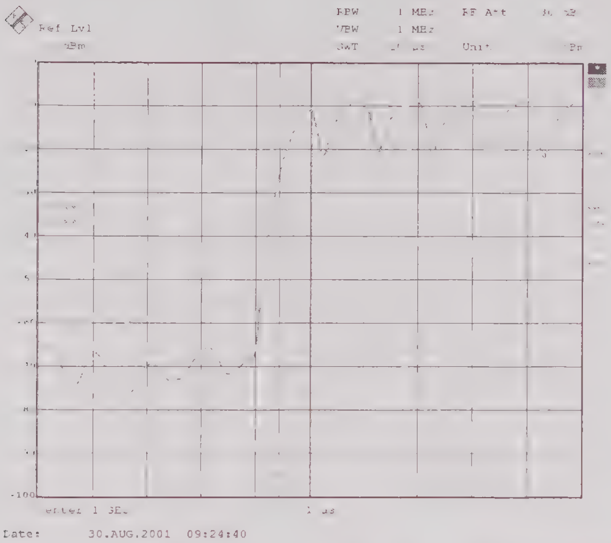


Fig. 15-31 Transition from idle time to active packet with (light-blue trace) and without (yellow trace) pulse modulation

An increase in the dynamic range of approx. 10 dB due to using the pulse modulator is clearly recognizable in the trace shwon above.

Note the following when optimizing the ON/OFF r tio:

- The pulse modulator should not respond in an area of high edge levels. Otherwise, the hard switching on/off of the pulse modulator will cause high amplitude steps in the signal in the time domain, and thus unwanted spurious in the spectrum. The Rise Offset should therefore be in the range of the negative half pulse lengths (see filter panel Impulse Length 32) and the Fall Offset in the range of positive half pulse length, where the I/Q signal has already very low levels.
- The pulse modulator must respond early enough to comply with the power time template required by the standard.

To meet these two requirements, a compromise must be found which provides both a clean spectrum, and is within the power time template.

16 1xEV-DO

WinIQSIM can generate 1xEV-DO signals. Section 16.1 gives an overview of this mobile radio standard. Section 16.2 then describes the associated control functions.

16.1 Description of Mobile Radio Standard 1xEV-DO

1xEV-DO is an enhanced version of the 1x mode of the North American standard cdma2000 for the third-generation mobile radio (3G). 1xEV-DO stands for cdma2000 **1x** Mode **Ev**olution **D**ata **O**nly. This enhanced version of the cdma2000 standard allows packet-oriented data transmission at a data rate of up to 2.4 Mbps in the 1.25 MHz-wide cdma2000 1x channel.
In addition to the Data Only mode, a mode for data and voice transmission (Data + Voice, 1xEV-DV) is currently being defined.

References:

[1] 3GPP2 C.S0024: cdma2000 High Rate Packet Data Air Interface Specification, Version 2.0, October 27, 2000

WinIQSIM simulates 1xEV-DO signals at the physical channel layer including channel coding. The following description is therefore limited to this layer.

The table below gives an overview of the main parameters of the 1xEV-DO system in WinIQSIM.

Table 16-1 Parameters of 1xEV-DO

Chip rate	1x (1.2288 Mcps)
Channel types of forward link	Forward pilot channel MAC RPC channel MAC RA channel Forward traffic channel
Channel types of reverse link	Reverse pilot channel Reverse data channel DRC channel ACK channel
Frame structure	Duration 26.66 ms, subdivided into 16 timeslots of 1.66 ms each.
Symbol rates	Forward: 38.4 kbps; 76.8 kbps; 153.6 kbps; 307.2 kbps; 307.2 kbps; 614.4 kbps; 614.4 kbps; 921.6 kbps; 1228.8 kbps; 1228.8 kbps; 1843.2 kbps; 2457,6 kbps Reverse: 9.6 kbps; 19.2 kbps; 38.4 kbps; 76.8 kbps; 153.6 kbps
Modulation	QPSK, 8PSK, 16QAM
PN offset	0 to 511
Channel coding	Modes: off, complete, without interleaving, interleaving only
Long code mask	0 to 3FF FFFF FFFF

16.1.1 System Components

The system configuration of 1xEV-DO on the forward and reverse link is shown below. This simplified diagram is used only to explain the system principle. A detailed description cannot be given in this manual. For further information refer to the standard (see [1]).

16.1.1.1 Forward Link

The following block diagram describes forward link generation of 1xEV-DO.

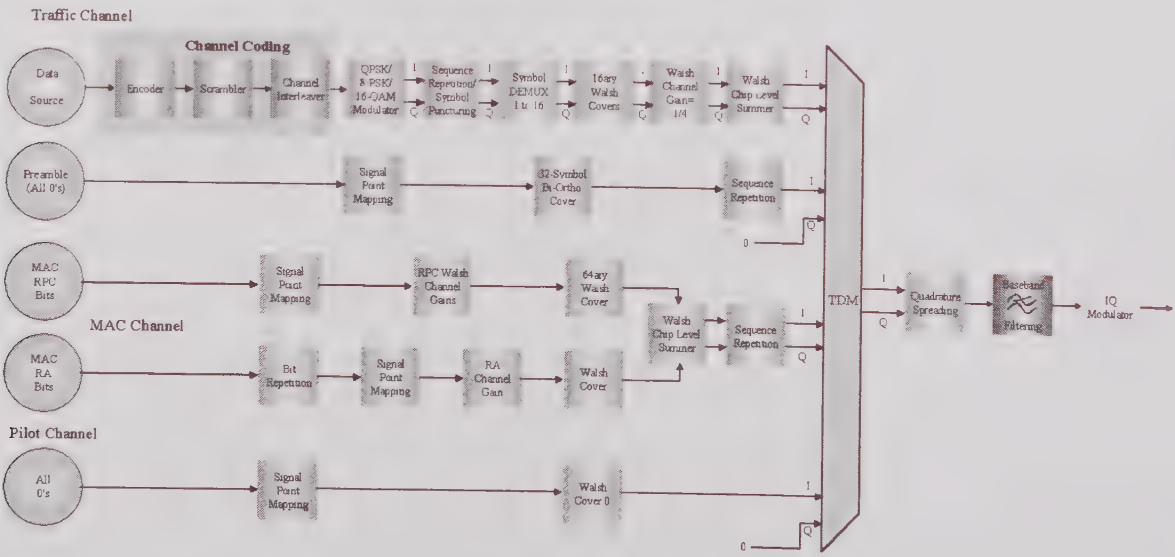


Fig. 16-1 Components of 1xEV-DO transmission system on the forward link

A frame in the forward link is divided into 16 slots. These slots can be used in time multiplex by different channels. The following figure shows a typical slot structure.

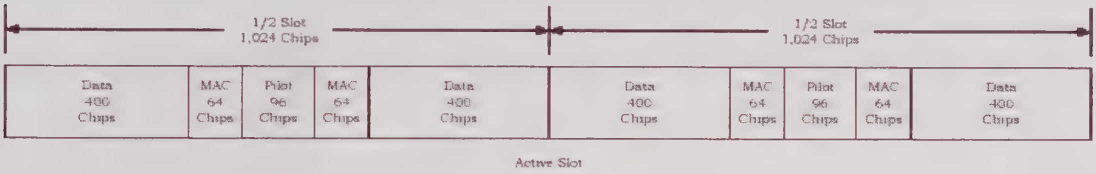


Fig. 16-2 Typical slot structure in forward link

A slot is additionally divided into half slots. Each of the half slots contains a (data) component originating from the traffic channel, and MAC and pilot channel components. In inactive slots, in which no data is transmitted, only MAC and pilot channels are sent.

Fig. 16-1 Components of 1xEV-DO transmission system on the forward link shows the individual channel structure. Each channel has a data source from where it gets its information. In the traffic channel, user data is transmitted (that will be channel-coded), control bits in both parts of the MAC channel and a sequence of 0 bits in the pilot channel. These channels and optionally also a preamble are sent in time multiplex in one slot. Depending on the data rate set in the traffic channel, one of the QPSK, 8PSK or 16QAM modulations will be used. The signal of the traffic channel is then divided into 16 elementary streams, each of which is spread by a 16-chip Walsh code. The elementary streams thus spread are added and time-multiplexed with the other channels. The quadrature spreading and baseband filtering blocks already known from cdma2000 will follow. Data is transmitted in packets. Depending on the set data rate of the traffic channel, either consecutive slots or timeslots separated by 4 slots are used. Data packets can then be sent to different receivers one after the other.
One part of the MAC channel is for power control of the access terminal (reverse power control RPC) and one for transmission of the reverse activity bits (MAC RA channel).
For further details see [1].

16.1.1.2 Reverse Link

A 1xEV-DO device on the reverse link may have two operating modes: the access mode used during call setup and the traffic mode used for the transmission of user data.
Signal generation depends on the mode as shown in the figures below.

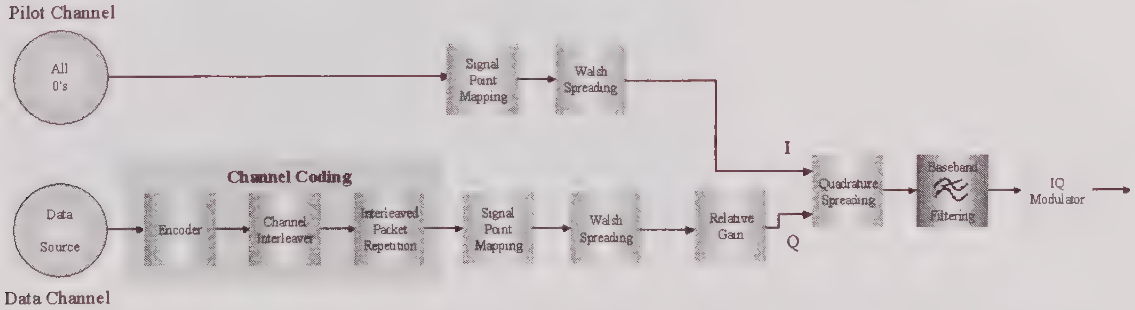


Fig. 16-3 Components of 1xEV-DO transmission system in access mode of reverse link

In the **access mode**, a continuous pilot channel is sent on the I path. Moreover, data is sent to the base station in access frames on the Q path for call setup. The I and Q components are then subjected to complex quadrature spreading and baseband filtering.

In the **traffic mode**, the pilot channel is time-multiplexed with the reverse rate indicator (RRI) channel. The RRI channel provides information on the rate used for data transmission on the reverse link. In addition to these two channels, also the data rate control channel is transmitted via the I path. In this channel, the access terminal informs the base station on the rate at which it wants to receive data from the base station. In addition to the traffic channel used for data transmission also the acknowledge channel is sent on the Q path. The acknowledge channel is used to confirm correct data packet reception to the base station. The I and Q components are then subjected to complex quadrature spreading and baseband filtering.

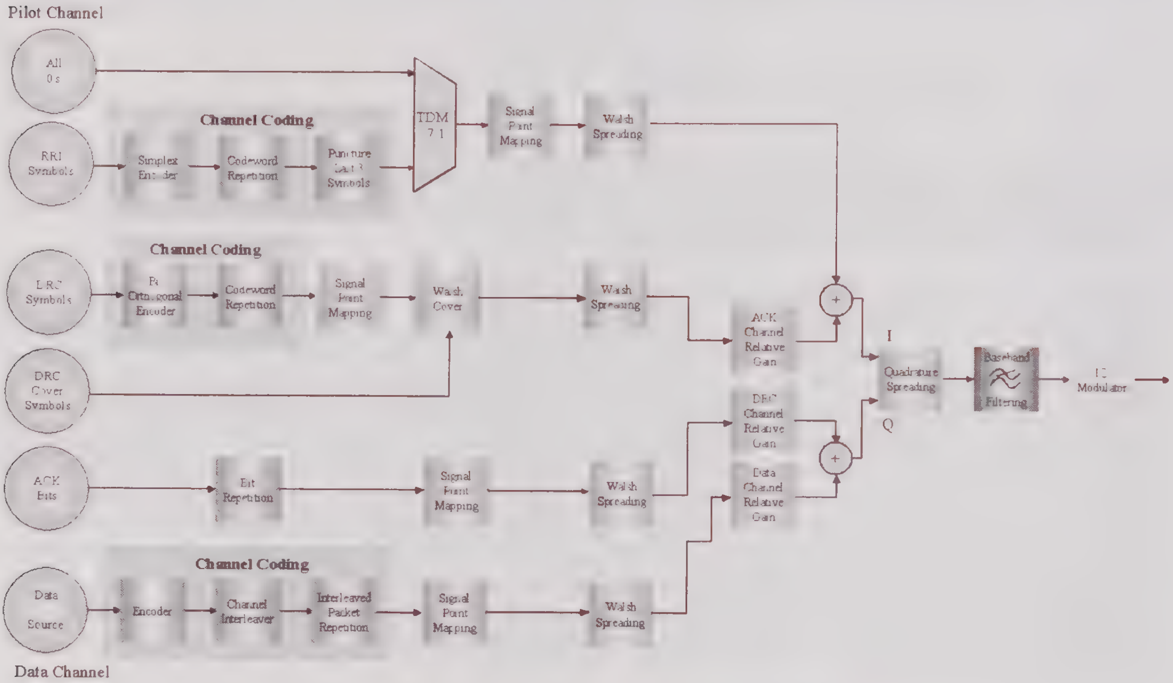
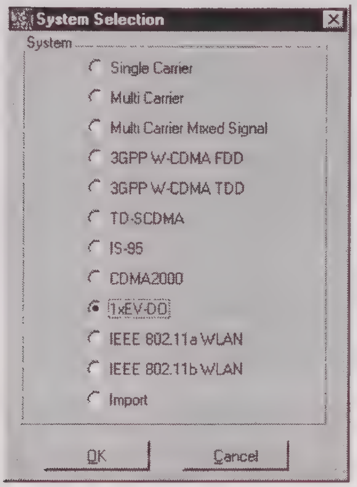


Fig. 16-4 Components of 1xEV-DO transmission system in traffic mode of reverse link

16.2 Generation of 1xEV-DO Signals with WinIQSIM

To generate a 1xEV-DO signal, the 1xEV-DO system must be selected first.



System Selection

System

- ○ Single Carrier
- ○ Multi Carrier
- ○ Multi Carrier Mixed Signal
- ○ 3GPP W-CDMA FDD
- ○ 3GPP W-CDMA TDD
- ○ TD-SCDMA
- ○ IS-95
- ○ CDMA2000
- ● 1xEV-DO
- ○ IEEE 802.11a WLAN
- ○ IEEE 802.11b WLAN
- ○ Import

Fig. 16-5 System selection 1xEV-DO

System selection is accessible from the File New... or System! menu.
The differences between the two methods are described in sections 5.22.1 and 5.23.

The 1xEV-DO block diagram is based on that of the single-carrier system. The data source block has been extended and the modulation block replaced by the 1xEV-DO configuration block.

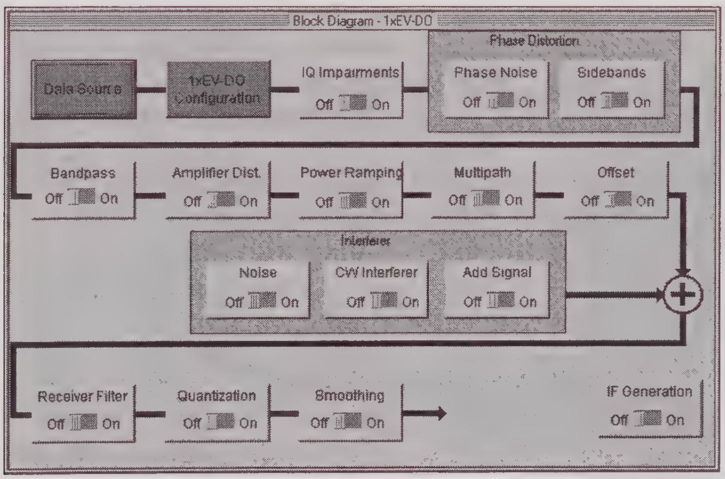


Fig. 16-6 Block diagram of 1xEV-DO system

The data source block corresponds to that of the multicarrier system. The data source is described in section 7.2.

16.2.1 Status Line

The main parameters of the 1xEV-DO transmission system are displayed in the status line below the toolbar of the main panel. The set parameters can thus be seen at a glance.

The status line contains symbols for the different parameters; below the symbols the current parameter values are indicated. The following figure shows the status line of the 1xEV-DO system. The parameters assigned to the symbols are displayed.

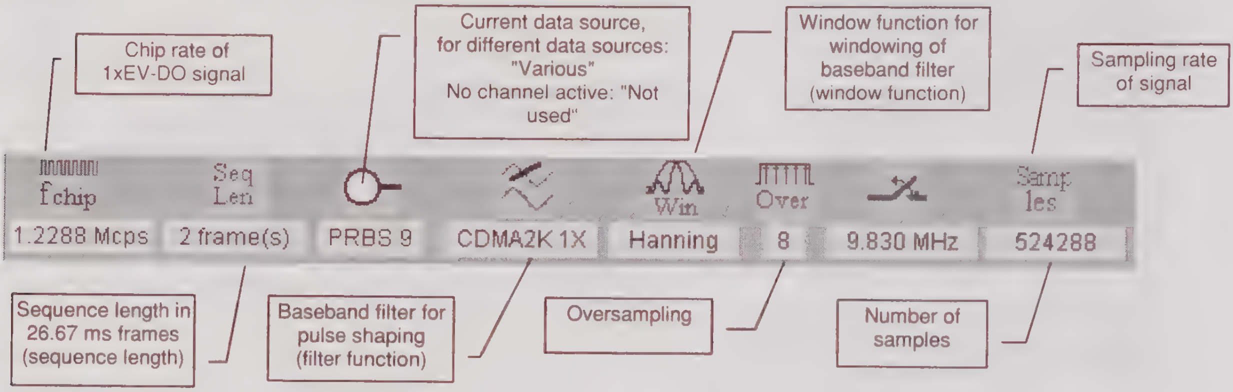
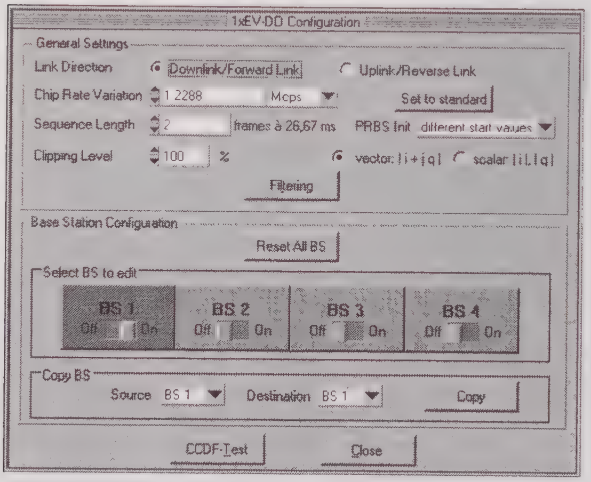

Chip rate of 1xEV-DO signal
Current data source, for different data sources: "Various" No channel active: "Not used"
Window function for windowing of baseband filter (window function)
Sampling rate of signal
fchip
Seq Len
Win
Over
Samp les
1.2288 Mcps
2 frame(s)
PRBS 9
CDMA2K 1X
Hanning
8
9.830 MHz
524288
Sequence length in 26.67 ms frames (sequence length)
Baseband filter for pulse shaping (filter function)
Oversampling
Number of samples

Fig. 16-7 Status line of 1xEV-DO system

16.2.2 1xEV-DO Configuration Panel

All parameters that are required for the definition of a 1xEV-DO signal (except data sources and impairments) can be accessed via the 1xEV-DO Configuration panel. The panels for the forward and reverse link are shown below.



Link Direction ● Downlink/Forward Link ○ Uplink/Reverse Link

Chip Rate Variation 1.2288 Mcps

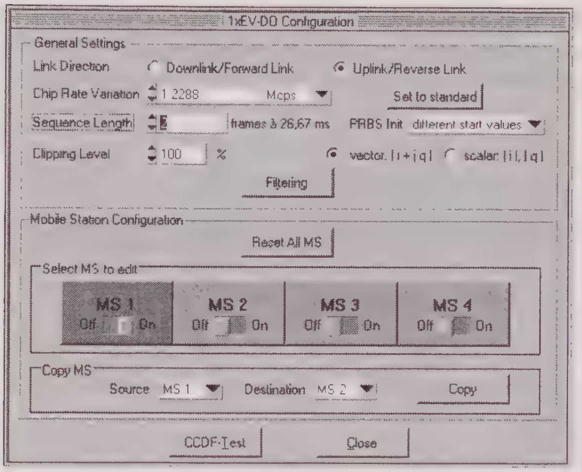
Sequence Length 2 frames à 26,67 ms

PRBS Init different start values

Clipping Level 100 % ● vector: |i + j q| ○ scalar |i|,|q|

Source BS 1 Destination BS 1

Fig 16-8 1xEV-DO Configuration panel of forward link


1xEV-DO Configuration

General Settings

Link Direction ○ Downlink/Forward Link ● Uplink/Reverse Link

Chip Rate Variation 1.2288 Mcps

Sequence Length 2 frames à 26,67 ms

PRBS Init different start values

Clipping Level 100 %

● vector: | i + j q | ○ scalar: | i |, | q |

Mobile Station Configuration

Copy MS: Source MS 1, Destination MS 2

Fig. 16-9 1xEV-DO Configuration panel of reverse link

16.2.2.1 General Settings

The following parameters are set in this panel.

- **Link Direction**
  Downlink/forward link (base station to the mobile station) or uplink/reverse link (mobile station to the base station). The lower section of the panel is adapted as a function of the link direction. In the downlink mode, the lower section is used to configure the base stations (access networks), in the uplink mode to configure the mobile stations (access terminals).

- **Chip Rate Variation**
  This parameter defines the actual chip rate of the output signal. This value defines the spread symbols rate used for an output by the AMIQ/SMIQ B60. It is normally set to the chip rate of 1.2288 Mcps defined by 1xEV-DO.

- **Set to standard**
  If this button is pressed, the chip rate variation parameter is automatically set to 1.2288 Mcps, i.e. the value defined by the standard.

- **Sequence Length**
  The length of the signal to be generated is set as "frames à 26.67 ms".
  A 1xEV-DO frame has the length of 32768 chips.

- **Clipping Level**
  Setting of clipping value relative to highest peak in percent. The setting range is 1 to 100%. A value of 100% means that the signal is not clipped. Clipping reduces the crest factor. Two different methods of clipping are offered.

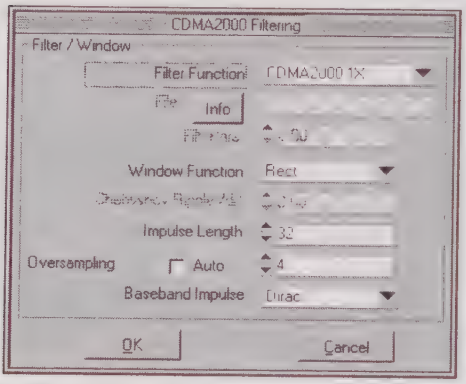
  vector | i+jq | : The instantaneous amplitudes | i+jq | are used as peak value
  scalar | i |,| q | : The absolute maximum of all I and Q values is used as peak value

- **PRBS Init, start values**
  This parameter allows to control initialization of the PRBS generators of the individual channels. The following modes are available:
  - **Same start values**: The PRBS generators of all channels are initialized with the same start value. The channels therefore use the same data.
  - **Different start values**: The PRBS generators of all channels are initialized with different start values. Different data are therefore used in the channels.
  - **Uncorrelated**: The data of all channels using "Data Source PRBS" are continuously taken from the same PRBS generator. Data in the individual channels is therefore no longer a subsequence of a PRBS sequence but the data of the channels is well decorrelated.

Note: *This parameter is only effective with 'Data Source PRBS' selected. If 'Data Source 0' is used for PRBS16, for instance, this parameter is ignored, i.e. all channels using 'Data Source 0' are calculated with identical PRBS bit sequences.*

16.2.2.2 Filtering

The generated raw chips are subjected to baseband filtering which is implemented in the same way as in the single-carrier system.


CDMA2000 Filtering

Filter / Window

Filter Function: CDMA2000 1X

Window Function: Rect

Impulse Length: 32

Oversampling: ☐ Auto 4

Baseband Impulse: Dirac

Fig. 16-10 1xEV-DO filtering

The individual parameters are therefore described in section 5.8, Modulation Settings Panel.

Note: *The 1xEV-DO standard defines the same baseband filters as cdma2000. On the forward link a filter is normally used that comprises an equalizer defined by the standard (CDMA2000 1x + equalizer (LEVM)). On the reverse link, it is recommended to use the filter defined by the standard (CDMA2000 1x). Since different filters are normally used for the two link directions, WinIQSIM stores the selected filters separately for both directions.*

16.2.2.3 Base Station/Mobile Station Configuration

With WinIQSIM up to 4 base stations or mobile stations of the 1xEV-DO system can be simulated at the same time.

16.2.2.3.1 Common Setting of all Base Stations/Mobile Stations

The base station/mobile station configuration window comprises several buttons the functions of which are described below. The functionality is the same for both link directions.

Reset All BS: All base stations are reset to predefined settings. For reset values see tables below.

Table 16-2 Reset values for base stations

Common parameters of BS	Reset value (BS 1, BS 2, BS 3, BS 4)
State	Off for all BS
PN offset	0
Coding	Off for all BS
Disable scrambling code	Off
Disable PN short code	Off
Preamble state	Off
Pilot state	Off

Parameters of code channels	Reset value (BS 1, BS 2, BS 3, BS 4)
Traffic channel	State off, MAC index 5, data rate 38.4 ksps, data source PRBS, data frame offset 0, 1 packet to send
MAC RA channel	State off, gain 0 dB, pattern "0", pattern repetition off, RAB length 1 slot, RAB offset 0
MAC RPC channel	State off for all MAC indexes (5 to 63): gain 0 dB, data pattern "0", state off

Reset All MS: All mobile stations are reset to predefined settings. For reset values see table below.

Table 16-3 Reset value for mobile stations

Common parameters of MS	Reset value (MS 1, MS 2, MS 3, MS 4)
State	Off for all MS
Coding	Off for all BS
Mode	Traffic
Disable PN short code	Off
Long code mask	0x0 for I and Q

Parameters of code channels	Reset value (MS 1, MS 2, MS 3, MS 4)
DRC channel	State off, power 0 dB, DRC value 38.4 ksps, start slot 0, cover 0, length 1 slot, gating off
ACK channel	State off, power 0 dB, start slot 1, ACK/NACK distance 1 slot, pattern "0"
Pilot/RRI channel	Pilot state off, RRI state off, power 0 dB
Traffic channel	State off, power 0 dB, 1 packet to send, reverse data rate 38.4 ksps, data source PRBS, data frame offset 0

Select BS/MS to edit: In this window, the base station/mobile stations are shown in the form of blocks. They can be switched on or off. Active BS/MS blocks are green, passive BS/MS blocks are grey. The currently active stations can thus be seen at a glance. To edit the parameters of a base station/mobile station, click the corresponding BS/MS block. A window is opened where the BS/MS can be configured (see also sections 16.2.3 and 16.2.4).

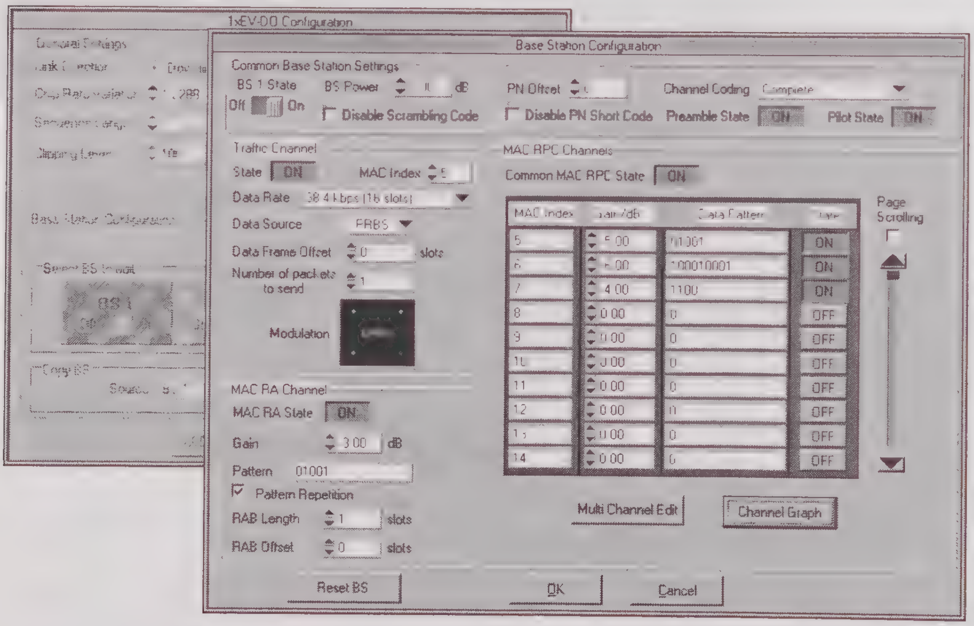
Copy BS/MS: In this window the configuration of one BS/MS can be copied for another BS/MS. Select the BS/MS to be copied in the Source field and the BS/MS to be overwritten in the Destination field. Start copying by pressing the Copy button. It is thus possible to generate a scenario of several BSs/MSs after configuring one BS/MS. Subsequently, only the BS/MS-specific parameters such as PN offset have to be modified to simulate different BSs/MSs.

CCDF Test: This button opens a window in which the 'complementary cumulative distribution function' is displayed. For further information see section 8.2.2.18**Fehler! Es wurde kein Textmarkenname vergeben.**.

Close: Pressing this button closes the 1xEV-DO Configuration panel.

16.2.3 Base Station Configuration

A click on one of the base station blocks in the 1xEV-DO Configuration panel opens the Base Station Configuration panel. The 1xEV-DO Configuration panel is also displayed but it is dimmed since the two windows are interrelated in many ways. The 1xEV-DO configuration parameters can still be read but not changed. When the Base Station Configuration panel is closed (with OK or Cancel), the 1xEV-DO Configuration panel is enabled again.



BS 1 State: On

BS Power: 0 dB

☐ Disable Scrambling Code

PN Offset: 0

☐ Disable PN Short Code

Channel Coding: Complete

Preamble State: ON

Pilot State: ON

State: ON

MAC Index: 5

Data Rate: 38.4 kbps (16 slots)

Data Source: PRBS

Data Frame Offset: 0 slots

Number of packets to send: 1

MAC RA State: ON

Gain: 3.00 dB

Pattern: 01001

☑ Pattern Repetition

RAB Length: 1 slots

RAB Offset: 0 slots

Common MAC RPC State: ON

MAC Index	Gain/dB	Data Pattern	State
5	5.00	01001	ON
6	6.00	100010001	ON
7	4.00	1100	ON
8	0.00	0	OFF
9	0.00	0	OFF
10	0.00	0	OFF
11	0.00	0	OFF
12	0.00	0	OFF
13	0.00	0	OFF
14	0.00	0	OFF

Fig. 16-11 Base Station Configuration panel

16.2.3.1 Common Base Station Settings

The parameters set in this window are valid for the complete base station.

BS State: The complete base station can be switched on or off.

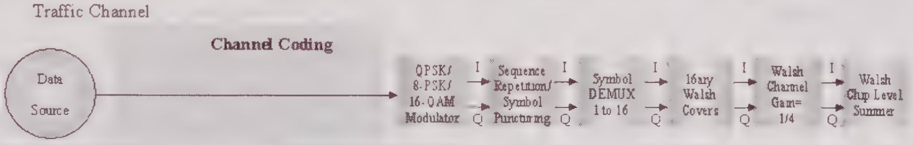
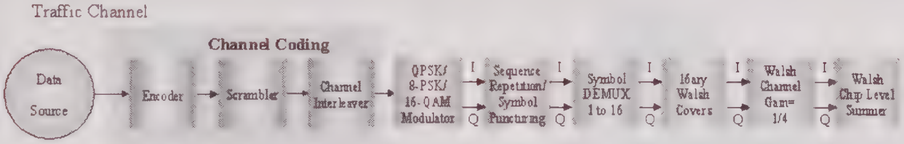
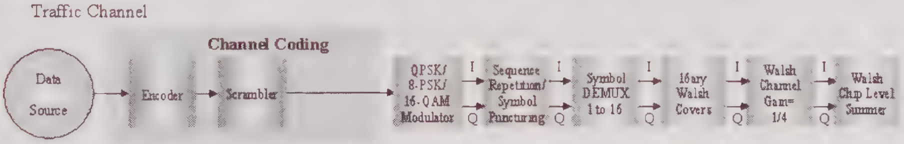
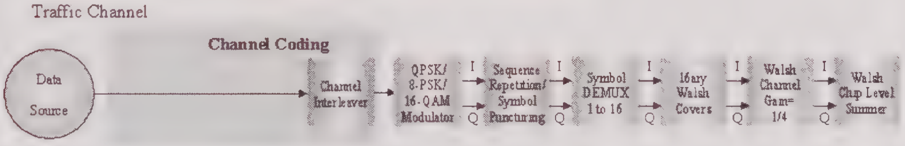
BS Power: The total power of the base station can be set.

PN Offset
A PN offset can be set for each base station. This value is used as time offset for the PN generators. Value range: 0 to 511.

Channel Coding

With this parameter you can decide whether the code channels of the base station should be channel-coded. To be able to test also individual parts of channel coding in your receiver, four coding modes are offered which are explained in the table below.

Table 16-4 Channel coding modes

Coding mode	Function / structure
Off	Channel coding is not performed. The data sources of the individual channels feed their data stream directly into the block signal point mapping or into the modulator block. The data source supplies the user data with the data rate that would be available at this block after coding is switched on.  Traffic Channel Channel Coding Data Source QPSK/ 8-PSK/ 16-QAM Modulator Sequence Repetition/ Symbol Puncturing Symbol DEMUX 1 to 16 16ary Walsh Covers Walsh Channel Gain= 1/4 Walsh Chip Level Summer I Q
Complete	The complete channel coding defined in the standard is performed.  Traffic Channel Channel Coding Data Source Encoder Scrambler Channel Interleaver QPSK/ 8-PSK/ 16-QAM Modulator Sequence Repetition/ Symbol Puncturing Symbol DEMUX 1 to 16 16ary Walsh Covers Walsh Channel Gain= 1/4 Walsh Chip Level Summer I Q
Without interleaving	Except for the interleaver block , the whole channel coding procedure is carried out. In this mode the frame structure and the coder of your receiver can be tested.  Traffic Channel Channel Coding Data Source Encoder Scrambler QPSK/ 8-PSK/ 16-QAM Modulator Sequence Repetition/ Symbol Puncturing Symbol DEMUX 1 to 16 16ary Walsh Covers Walsh Channel Gain= 1/4 Walsh Chip Level Summer I Q
Interleaving only	In this mode only the interleaver block is used for coding. This allows the deinterleaver in the receiver to be tested independently of the remaining (de-)coding process.  Traffic Channel Channel Coding Data Source Channel Interleaver QPSK/ 8-PSK/ 16-QAM Modulator Sequence Repetition/ Symbol Puncturing Symbol DEMUX 1 to 16 16ary Walsh Covers Walsh Channel Gain= 1/4 Walsh Chip Level Summer I Q

Disable Scrambling Code

The use of the scrambling code on the data stream can be switched off with this option.

Disable PN Short Code

The use of the PN short code on the data stream can be switched off with this option.

Preamble State

This switch allows the preamble to be added, which is sent before the other signal components (see also Fig. 16-1 Components of 1xEV-DO transmission system on the forward link).

Pilot state

T

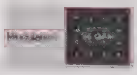
With this switch the pilot channel can be switched on or off (see also Fig. 16-1 Components of 1xEV-DO transmission system on the forward link and Fig. 16-2 Typical slot structure in forward link).

16.2.3.2 Traffic Channel Parameters

The actual user data is transmitted in the traffic channel. Depending on the data rate and the number of packets to be sent, consecutive slots are used or slots spaced by 4 as defined by the standard. For more detailed information refer to [1], section 9.3.1.3.1, Forward Channel Structure.

State
This button allows to switch the complete traffic channel on or off.

MAC Index
The index of the medium access control (MAC) channel assigned to the traffic channel can be set.
Value range: 0 to 63

Data Rate
In this field, the data rate of the traffic channel can be defined. In addition to the data rate, the number of slots stipulated by the standard to transmit a data packet of this rate is also specified. These slots of a data packet are spaced by 4 slots. Selection of the data rate automatically determines the modulation type (QPSK, 8PSK or 16QAM). The modulation currently used in the traffic channel is displayed in the Modulation field .

Example: data rate 153.6 ksps (4 slots)
To send a data packet, data is sent in 4 slots spaced by 4 slots.

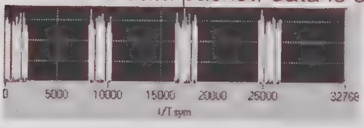


Fig. 16-12 Subpacket at a data rate of 153.6 ksps (4 slots)

Data rates defined by the standard are specified in the table below.

Data Rate (kbps)	Number of Values per Physical Layer Packet				
	Slots	Bits	Code Rate	Modulation Type	TDM Chips (Preamble, Pilot, MAC, Data)
38.4	16	1,024	1/5	QPSK	1,024 3,072 4,096 24,576
76.8	8	1,024	1/5	QPSK	512 1,536 2,048 12,288
153.6	4	1,024	1/5	QPSK	256 768 1,024 6,144
307.2	2	1,024	1/5	QPSK	128 384 512 3,072
614.4	1	1,024	1/3	QPSK	64 192 256 1,536

Data Rate (kbps)	Number of Values per Physical Layer Packet				
	Slots	Bits	Code Rate	Modulation Type	TDM Chips (Preamble, Pilot, MAC, Data)
307.2	4	2,048	1/3	QPSK	128 768 1,024 6,272
614.4	2	2,048	1/3	QPSK	64 384 512 3,136
1,228.8	1	2,048	1/3	QPSK	64 192 256 1,536
921.6	2	3,072	1/3	8-PSK	64 384 512 3,136
1,843.2	1	3,072	1/3	8-PSK	64 192 256 1,536
1,228.8	2	4,096	1/3	16-QAM	64 384 512 3,136
2,457.6	1	4,096	1/3	16-QAM	64 192 256 1,536

Fig. 16-13 Data rates on forward link

Data Source

One of the four data sources Data 0, Data 1, Data 2 or PRBS is selected for user data. For the definition of data sources see section 7.2.

Data Frame Offset

This parameter defines the slot of the frame in which data transmission is to be started.
Value range: 0 to 3.

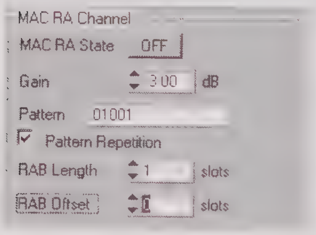
Number of Packets to send

The number of the data packets to be sent is defined. Each new data packet directly follows the previous one. With data rates using more than one slot for transmitting a packet, the first slot of the next packet follows the last slot of the previous packet with a spacing of 4 slots.
Value range: 0 to 2000.

Note: The number of packets to be transmitted does not automatically set the sequence length in frames (1xEV-DO Configuration panel) in such a way that all packets are generated. To ensure that all packets are generated the sequence must be long enough:
(number of packets * slots per packet * subpacket spacing + 15) / 16 = minimum number of frames, with a subpacket spacing of 1 (if the packet can be transmitted in one slot) or 4.
Since other useful settings are available allowing to generate more frames (idle frames) than required for packet transmission and since different sequence lengths may be required due to the combination of different BS, automatic setting is not possible.

16.2.3.3 MAC RA Channel Parameters

In the MAC reverse activity (RA) channel, the reverse activity bit stream is transmitted via the MAC channel using the MAC index 4.


MAC RA Channel

MAC RA State: OFF

Gain: 3.00 dB

Pattern: 01001

☑ Pattern Repetition

RAB Length: 1 slots

RAB Offset: 0 slots

Fig. 16-14 MAC RA channel on forward link

MAC RA State
This button allows to switch the complete MAC RA channel on or off.

Gain
This parameter allows to weigh the MAC RA channel against the subchannels of the MAC RPC. The total power of MAC RA channel and of all MAC RPC subchannels is normalized so that it corresponds to the power of the traffic channel.
Value range: -80 dB to 0 dB.

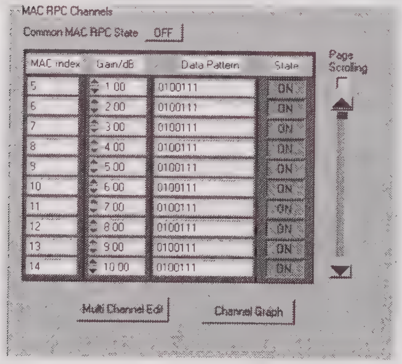
Pattern
In this field, a data pattern with a length of up to 16 bits, the MAC RA bits, can be entered. Each bit is repeated 4 times in each slot and each RAB_length slot until the pattern is completed. If the **Pattern repetition** option is selected, the pattern is cyclically repeated.

RAB Length
In this field, the number of slots used for RA bit transmission can be set.
Value range: 0 to 100 slots.

RAB Offset
This parameter allows to delay the beginning of the MAC RA channel by the set number of slots.
Value range: 0 to 15 slots.

16.2.3.4 MAC RPC Channel Parameters

The MAC reverse power control (RPC) channel consists of up to 59 subchannels used to control the output power of the access terminals (mobiles). A different MAC index (5 to 63) is assigned to each subchannel.


MAC RPC Channels

Common MAC RPC State: OFF

MAC index	Gain/dB	Data Pattern	State
5	1.00	0100111	ON
6	2.00	0100111	ON
7	3.00	0100111	ON
8	4.00	0100111	ON
9	5.00	0100111	ON
10	6.00	0100111	ON
11	7.00	0100111	ON
12	8.00	0100111	ON
13	9.00	0100111	ON
14	10.00	0100111	ON

Fig. 16-15 MAC RPC channel on forward link

Common MAC RPC State
With this button the complete MAC RA channel can be switched on or off.

Gain
This parameter allows to weigh a MAC RPC subchannel assigned to a MAC index against the other subchannels of the MAC RPC. The total power of MAC RA and of all MAC RPC subchannels is normalized so that it corresponds to the power of the traffic channel.
Value range: -80 dB to 0 dB.

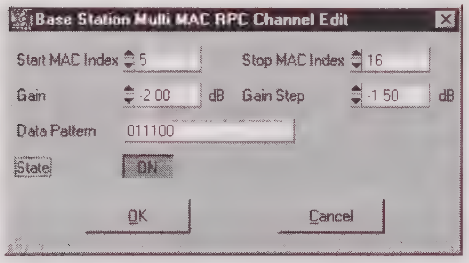
Data Pattern
A data pattern with a length of up to 16 bits, the MAC RPC bits, can be entered. The pattern will be cyclically repeated.

State (MAC RPC subchannel)
With this button a complete MAC RPC subchannel can be switched on or off.

Channel Graph
With this button a graph is displayed where active MAC RPC subchannels and their power can be seen at a glance.

16.2.3.5 MAC RPC Multichannel Edit

Several MAC RPC subchannels can be set together in this window.


Base Station Multi MAC RPC Channel Edit

Start MAC Index 5
Stop MAC Index 16
Gain -2.00 dB
Gain Step -1.50 dB
Data Pattern 011100
State ON

Fig. 16-16 MAC RPC Multichannel Edit

The **Start MAC index** and **Stop MAC index** parameters define the range of the subchannels to be edited together. **Gain** is used to define the gain and **Gain step** to define the step width of the gain consecutively for each channel. **Data pattern** and **State** are used to define the RPC bits of the channels and their state.

16.2.4 Mobile Station Configuration

A click on one of the mobile station blocks in the 1xEV-DO Configuration panel opens the Mobile Station Configuration panel. The 1xEV-DO Configuration panel is also displayed but is dimmed since the two windows are interrelated in many ways. The 1xEV-DO Configuration parameters can still be read but not changed. When the Mobile Station Configuration panel is closed (with OK or Cancel), the 1xEV-DO Configuration panel is enabled again.

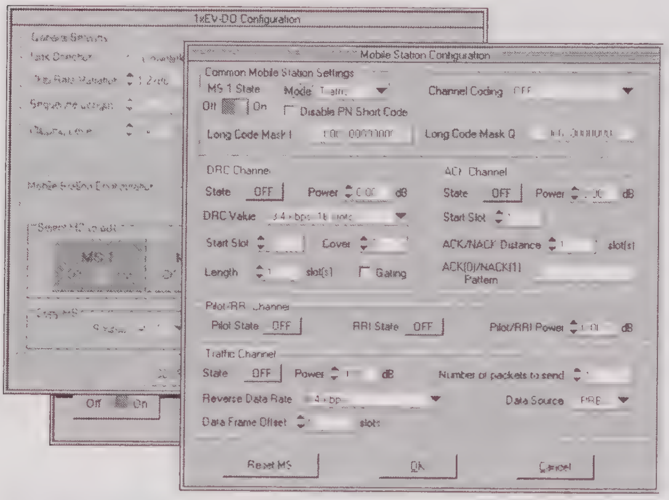


Fig. 16-17 Mobile Station Configuration panel in traffic mode

16.2.4.1 Common Mobile Station Settings

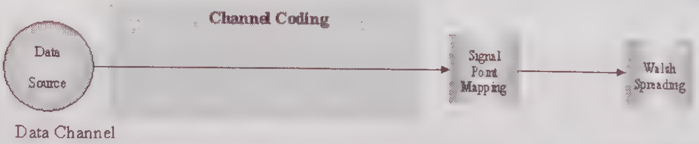
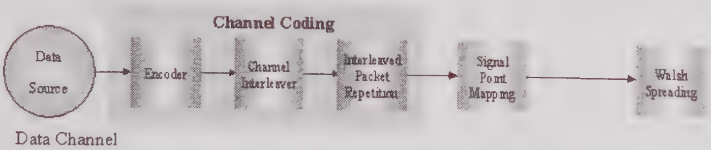
In this window, parameters valid for the complete mobile station can be set.

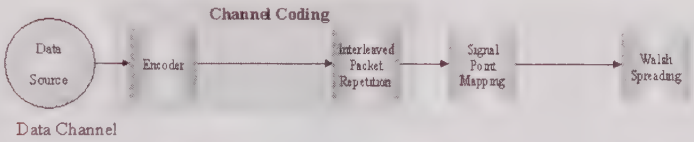
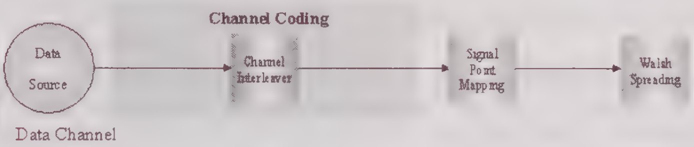
MS State: Here the complete mobile station can be switched on or off.

Mode
On the reverse link, a 1xEV-DO device may have two operating modes: the Access mode used for call setup and the Traffic mode used for transmission of user data. Signal generation depends on the selected mode. The operating window is automatically adapted to the selected mode.

Channel Coding
This parameter allows to decide whether the code channels of the mobile station should be channel-coded. To be able to test also individual sections of channel decoding in your receiver, four coding modes are offered which are explained in the table below.

Table 16-5 Channel coding modes

Coding mode	Function / structure
Off	Channel coding is not performed. The data sources of the individual channels apply their data stream directly to the signal point mapping block. The data source supplies the user data with the data rate that would be available at this block after coding is switched on.  Channel Coding Data Source Signal Point Mapping Walsh Spreading Data Channel
Complete	The complete channel coding defined by the standard is performed.  Channel Coding Data Source Encoder Channel Interleaver Interleaved Packet Repetition Signal Point Mapping Walsh Spreading Data Channel
Without interleaving	Except for the interleaver block, the whole channel coding process is carried out. In this mode the

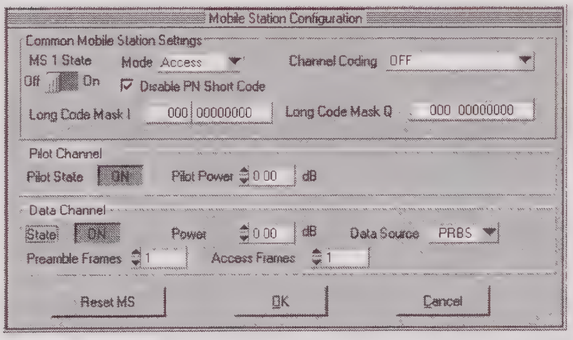
	frame structure and the encoder of your receiver can be tested.  Channel Coding Data Source Encoder Interleaved Packet Repetition Signal Point Mapping Walsh Spreading Data Channel
Interleaving only	In this mode only the interleaver block is used for coding. This allows the deinterleaver in the receiver to be tested independently of the remaining (de)coding process.  Channel Coding Data Source Channel Interleaver Signal Point Mapping Walsh Spreading Data Channel

Disable PN Short Code
The use of the PN short code on the data stream can be switched off with this option.

Long Code Mask I / Q
The mask of the long code generator used for the I or Q component can be defined. The mask is to be specified in hexadecimal form. The long-code mask is a 42-bit value that can be entered in two parts, as a high 10-bit word and a low 32-bit word. The range is 0 to 3FF FFFF FFFF. The mask serves for channel-specific and user-specific scrambling of the code channel.

16.2.4.2 Access Mode

In the access mode, the Mobile Station Configuration panel has the following structure:



Mobile Station Configuration

Common Mobile Station Settings

MS 1 State Off On

Mode Access

Channel Coding OFF

☑ Disable PN Short Code

Long Code Mask I 000 00000000

Long Code Mask Q 000 00000000

Pilot Channel

Pilot State ON

Pilot Power 0.00 dB

Data Channel

State ON

Power 0.00 dB

Data Source PRBS

Preamble Frames 1

Access Frames 1

Fig. 16-18 Mobile Station Configuration panel in access mode

In this case the uplink signal consists of the pilot channel and the data or traffic channel.

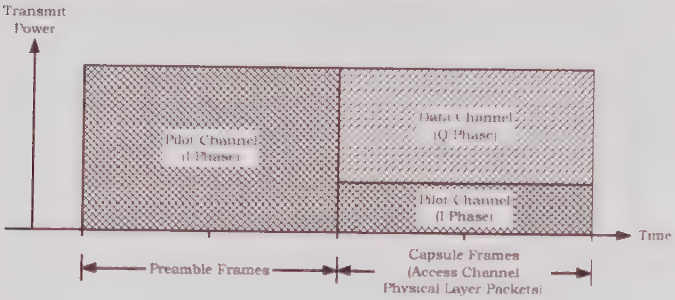


Fig. 16-19 Signal structure in access mode

In the access mode, the preamble frames are sent first. Only the pilot is active in these frames. The preamble frames are followed by access frames in which the pilot channel and data channel are active. The total transmit power remains constant. The power parameters offered in WinIQSIM for pilot and data power refer to the access frames. The pilot power in the preamble frames is automatically adapted.

Pilot State
The pilot channel can be switched on or off by means of this switch (see also Fig. 16-3 Components of 1xEV-DO transmission system in access mode of reverse link).

Pilot Power
With this parameter, the power of the pilot channel can be set.
Range: -80 dB to 0 dB.

Data Channel State
With this switch, the data or traffic channel can be switched on or off (see also Fig. 16-3 Components of 1xEV-DO transmission system in access mode of reverse link).

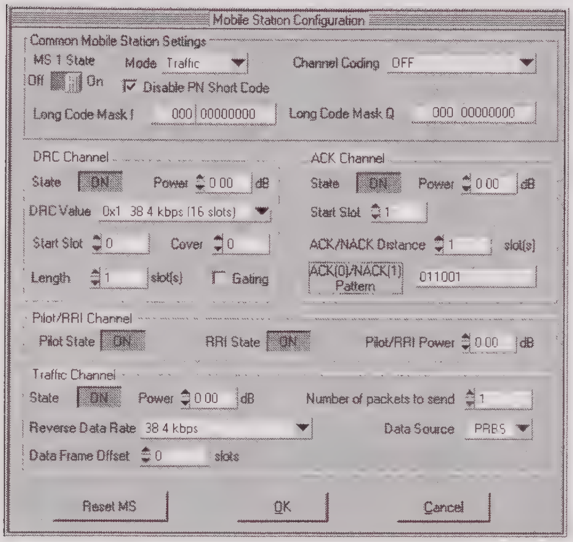
Data Channel Power
With this parameter, the power of the data channel can be set.
Value range: -80 dB to 0 dB.

Data Source
One of the four data sources Data 0, Data 1, Data 2 or PRBS is selected as source for the user data of the data channel. For the definition of data sources see section 7.2.

Preamble/Access Frames
The data channel consists of a settable number of preamble frames followed by access frames. 1 to 10 frames can be selected for each parameter.

16.2.4.3 Traffic Mode

In the traffic mode, the Mobile Station Configuration panel has the following structure:



Mobile Station Configuration

Common Mobile Station Settings
MS 1 State Off On
Mode Traffic
Channel Coding OFF
☑ Disable PN Short Code
Long Code Mask I 000 00000000
Long Code Mask Q 000 00000000

DRC Channel
State ON
Power 0.00 dB
DRC Value 0x1 38.4 kbps (16 slots)
Start Slot 0
Cover 0
Length 1 slot(s)
☐ Gating

ACK Channel
State ON
Power 0.00 dB
Start Slot 1
ACK/NACK Distance 1 slot(s)
ACK(0)/NACK(1) Pattern 011001

Pilot/RRI Channel
Pilot State ON
RRI State ON
Pilot/RRI Power 0.00 dB

Traffic Channel
State ON
Power 0.00 dB
Number of packets to send 1
Reverse Data Rate 38.4 kbps
Data Source PRBS
Data Frame Offset 0 slots

Fig. 16-20 Mobile Station Configuration panel in traffic mode

In the traffic mode, the uplink signal consists of the data rate control (DRC) channel, the acknowledge (ACK) channel, the pilot channel, the reverse rate indicator (RRI) channel and the traffic channel.

16.2.4.3.1 DRC Channel

In the DRC channel, the access terminal (mobile station) informs the access network (base station) about the data rate the access terminal wants to receive in the forward link (requested data rate).

State
The DRC channel can be switched on or off.

Power
The power of the DRC channel can be set by means of this parameter.
Value range: -80 dB to 0 dB.

DRC Value
The DRC value implicitly indicates the data rate requested by the access terminal from the base station. DRC values between 0x0 and 0xF are defined in the standard. These values are assigned to the data rates in the forward link as shown in the table below. DRC values 0xD to 0xF are not permissible and are therefore not offered in WinIQSIM.

DRC value	Rate (kbps)	Packet Length (Slots)
0x0	null rate	N/A
0x1	38.4	16
0x2	76.8	8
0x3	153.6	4
0x4	307.2	2
0x5	307.2	4
0x6	614.4	1
0x7	614.4	2
0x8	921.6	2
0x9	1228.8	1
0xa	1228.8	2
0xb	1843.2	1
0xc	2457.6	1
0xd	Invalid	N/A
0xe	Invalid	N/A
0xf	Invalid	N/A

Fig. 16-21 Assignment of DRC value and requested data rate

Start Slot
Definition in which slot the DRC channel generation is to be started.
Range: slot 0 to 7.

Cover
The DRC channel is spread with a Walsh code of the length 8. One of the eight Walsh codes provided can be selected.
Value range: 0 to 7.

Length
Definition of the duration of the DRC channel. Lengths between 1 and 8 slots can be set.

Gating
With DRC gating activated, the DRC value is only transmitted in the first of the set DRC length slots. The channel is inactive in the following slots.

16.2.4.3.2 ACK Channel

The access terminal informs the base station in the ACK channel whether a packet transmitted in the forward traffic channel has been received successfully. A 0 bit sent on the ACK channel indicates that the packet has correctly been received, a 1 bit indicates that the packet has been received incorrectly or not at all. If the ACK channel is active in a slot, it only occupies the first 1024 chips. It is blanked in the remaining slot.

State
The ACK channel can be switched on or off.

Power
The power of the ACK channel can be set by means of this parameter.
Value range: -80 dB to 0 dB.

Start Slot
Definition in which slot the ACK channel generation is to be started.

Value range: slot 0 to slot 7.

ACK/NACK Distance
Definition with which spacing the ACK/NACK bits are sent. An ACK channel slot is generated for each bit of the ACK/NACK pattern.
Value range: slot 1 to slots 8.

ACK(0)/NACK(1) Pattern
Definition of the ACK (0 bit) / NACK (1 bit) sequence to be sent. An ACK channel slot is generated for each bit of the pattern.

16.2.4.3.3 Pilot/RRI Channel

The pilot and the RRI channel are sent in time-multiplex on the same Walsh channel and with the same power. In the RRI channel, the access terminal is informed of the data rate it uses in the data or traffic channel. With WinIQSIM, the reverse data rate parameter is automatically used in the traffic channel section.

Pilot State
The pilot channel can be switched on or off.

RRI State
The RRI channel can be switched on or off.

Pilot/RRI Power
With this parameter, the power of the pilot and the RRI channel can be set together.
Value range: -80 dB to 0 dB.

16.2.4.3.4 Traffic Channel

The traffic channel is used to transmit user data to the base station. Consecutive slots and frames are used until all data to be sent is transmitted.

State
The traffic channel can be switched on or off.

Power
The power of the traffic channel can be set by means of this parameter.
Value range: -80 dB to 0 dB.

Number of packets to send
The number of data packets to be sent is specified. Each new data packet is sent immediately after the previous data packet and occupies a frame.
Value range: 0 to 100.

Reverse Data Rate
In this field, the data rate of the traffic channel can be defined. The following rates can be chosen:

Data Rate (kbps)	RRI Symbol
0	000
9.6	001
19.2	010
38.4	011
76.8	100
153.6	101

Fig. 16-22 Reverse data rates and assigned RRI values

Data Source
One of the four data sources Data 0, Data 1, Data 2 or PRBS is selected as source for the user data. For the definition of data sources see section 7.2.

Data Frame Offset
This parameter defines the slot in the frame in which data transmission is to be started.
Value range: 0 to 3.

17 IEEE 802.11a Wireless LAN

WinIQSIM can generate signals according to the Wireless LAN standard IEEE 802.11a (referred to as 802.11a). Section 17.1 first gives an overview of this standard. Section 17.2 describes the associated control elements. Section 17.3 provides further information on the generation of 802.11a signals.

17.1 Description of Wireless LAN Standard IEEE 802.11a

'IEEE 802.11a' stands for a wireless LAN standard prepared by ANSI/IEEE. A brief description of the standard is given in the following. For a detailed description see the corresponding ANSI/IEEE specifications (see References below) that are also available at **http://standards.ieee.org/getieee802/**.

References:

[1] ANSI/IEEE Std 802.11, 1999 Edition: Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

[2] IEEE Std 802.11a-1999 (Supplement to ANSI/IEEE Std 802.11, 1999 Edition): Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher-Speed Physical Layer in the 5 GHz Band

WinIQSIM simulates 802.11a at the physical layer. The following description therefore refers to this layer.

17.1.1 Development of 802.11 Standard

In 1990, IEEE founded the work group 802.11 which issued a first version of the 802.11 standard in June 1997. This standard defines two transmission methods: an infrared interface and radio transmission in the ISM band around 2.4 GHz.
In spring 1999, the standard was extended by an OFDM mode, 802.11 a, in the 5 GHz band. The structure of the physical layer (PHY) and of the physical layer convergence protocol (PLCP) is briefly described in the following.

17.1.2 Packet Structure of 802.11a at the Physical Layer

Wireless LAN Standard 802.11a is a packet-oriented method for data transmission. Transmission and reception of data packets - also called frames - is performed at the same frequency in the TDD (time division duplex) mode, however without a fixed timeslot raster. A 802.11a component can be used simultaneously either for transmission or reception. The basic packet structure is described in the following.

17.1.2.1 OFDM Modulation

The standard defines OFDM (orthogonal frequency division multiplex) with 52 carriers as transmission method. The symbol rate of the modulation on the individual carriers is 250 kHz. A user data rate of up to 54 Mbps at a channel bandwidth of 20 MHz can be obtained by combining 48 useful carriers for data transmission (4 carriers are used for pilots) and using 64QAM for subcarrier modulation. With OFDM, the individual carriers are superimposed mutually orthogonal, which, in the ideal case, does not cause any intercarrier interference (ICI).

Table 17-1: Parameters of 802.11a OFDM modulation

Parameters	Value
Number of data subcarriers	48
Number of pilot subcarriers	4
Total of subcarriers used	52
Subcarrier frequency spacing	0.3125 MHz (= 20 MHz/64)
IFFT/FFT period	3.2 µs
Guard interval duration	0.8 µs (T_{FFT} /4)
Symbol interval	4 µs (T_{GI} + T_{FFT})
PLCP preamble duration	16 µs
Subcarrier modulation	BPSK OFDM QPSK OFDM 16QAM OFDM 64QAM OFDM
Error correction code	K = 7 (64 states) convolutional code
Code rates	1/2, 2/3, 3/4
Occupied bandwidth	16.6 MHz
Channel spacing	20 MHz

Table 17-1: Parameters of 802.11a OFDM modulation shows the main parameters of OFDM. 64-point IFFT is used to generate the 52 subcarriers. 12 of the 64 possible carriers are not used. One is the carrier in the middle of the band, which would otherwise be impaired by the carrier leakage of the I/Q modulator, the others are the remaining carriers at the upper and lower end of the spectrum. The required subcarrier offset of 312.5 kHz is implicitly observed when the time signal generated by the IFFT with a sampling rate of 20 MHz is output. These 20 MHz are also called 'kernel sample rate'. An OFDM symbol generated in this way would have a period of 3.2 µs. To compensate for multipath propagation, a so-called guard interval with a duration of 0.8 µs is attached to each symbol so that a total symbol interval of 4 µs is obtained.

Either BPSK, QPSK, 16QAM or 64QAM modulation can be used on the subcarriers. Prior to the modulation, the raw data are convolutionally coded with code rates of ½ to ¾ being possible.

17.1.2.2 PLCP Format

The physical layer convergence protocol (PLCP) is a protocol layer between medium access control and the actual physical transmission layer (PHY). It is mainly used to adapt the different transmission formats of the 802.11 standards to the MAC layer which is identical for all transmission methods. Moreover, this protocol informs the receiver on the type of signal sent to allow for a correct demodulation.
The PLCP generates the PLCP protocol data unit (PPDU) frames which are physically transmitted. The frame structure can be seen in the figure below:

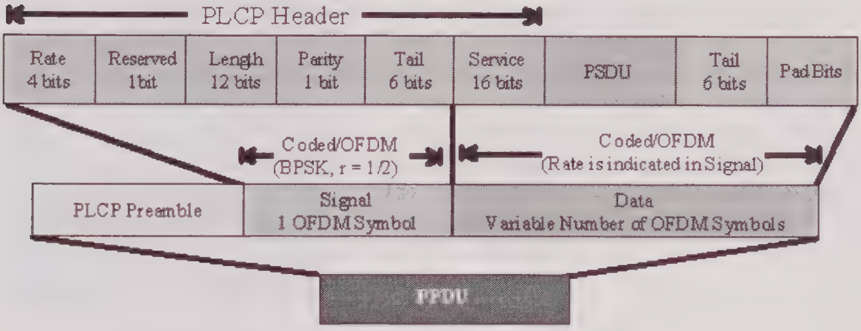


Fig. 17-1: PLCP format

17.1.2.2.1 PLCP Preamble

Each frame starts with the PLCP preamble made up of 10 short and 2 long symbols. The receiver uses the short symbols mainly for signal detection, AGC, coarse frequency adjustment and time synchronization. The long symbols are used to determine the transmission function of the channel and to set the equalizer of the receiver accordingly. The complete preamble is 16 µs long and thus corresponds to the duration of 4 normal OFDM symbols.
WinIQSIM loads a precalculated preamble from the IEEE802.11a_PLCP-preamble.pbl file in the 802_11a_preamble directory. The file comprises the I/Q values of the preamble and is identical with the preamble supplied with WinIQOFDM.

17.1.2.2.2 Signal Field

The signal field directly follows the preamble and consists of 24 bits which are used as follows:

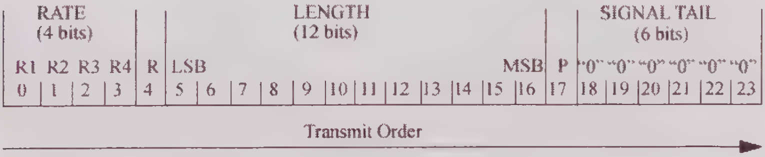


Fig. 17-2: Signal field

The first 4 bits inform on the data rate (RATE) of the following data section. This allows the receiver to correctly set its demodulator. Following a reserved bit, 12 LENGTH bits are sent. They contain the number of bytes transmitted in this frame. After a parity bit, 6 tail bits reset the convolutional coder to zero.
With settings for 6 Mbps, the 24 bits are subjected to usual signal processing consisting of convolutional coding, interleaving, BPSK subcarrier modulation, pilot carrier generation and OFDM modulation and thus form exactly one OFDM symbol of 4 µs duration. Thanks to the use of the lowest data rate (6 Mbps), each receiver has the best chance to obtain the information required for subsequent demodulation of the data section.

17.1.2.2.3 Data

The user data in the data section of the frame is finally taken to the receiver. The data section may have a variable length of OFDM symbols and can be transmitted with one of the defined data rates between 6 and 54 Mbps. The data section of the frame is subdivided into the fields SERVICE, PSDU, TAIL and Pad bits.

SERVICE 16 bits	PSDU	TAIL 6 bits	Pad bits

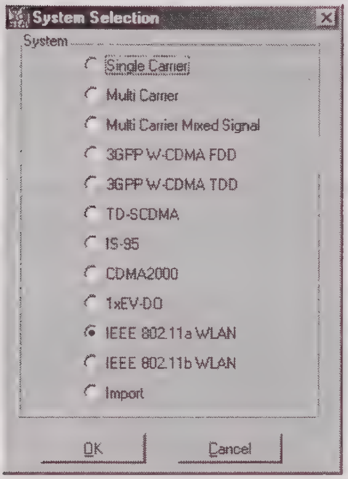
The service field consists of 16 bits, the 7 LSBs transmitted first being 0. The allows the receiver to draw conclusions as to the start value of the scrambler in the transmitter. The remaining 9 bits are reserved and, according to the current version of the standard, should also be set to 0.
The PSDU may have a user-selectable length of up to 2346 bytes. 6 tail bits follow to reset the convolutional coder to zero. The data field must be filled with the full number of OFDM symbols and is therefore rounded up. Additional bits that may be available are set to 0 as pad bits.
A short description of the individual steps required to attain a valid 802.11a signal follows.
Data from the source (usually the next higher protocol layer, here MAC) must first be scrambled, i.e. multiplied with a PN sequence. A 127-bit code generated by the following generator polynomial is stipulated:

$$S(x) = x^7 + x^4 + 1$$

A feedback shift register generates the scrambling sequence. The start value of the register for the data section should be randomly selected.
A subsequent convolutional coder adds redundancies to the bits thus scrambled (factor of 2). The coder has 64 possible states (k = 7) and is described by the polynomials $g_0=133_8$ and $g_1=171_8$. To obtain the data rates of 6 to 54 Mbps defined by the standard, different channel code rates are required. Bits generated by the convolutional coder are therefore punctured (i.e. omitted) depending on the setting so that 1/2, 2/3 or 3/4 code rates are attained. Increasing the redundancy by channel coding is generally mandatory in case of OFDM modulations since complete subcarriers may be eliminated by frequency selective fading so that the loss of bits on the transmission path is in many cases unavoidable.
To increase the performance of the convolutional coder, the coded data are interleaved in the next step. Two interleaver stages ensure that the adjacent bits of the convolutional coder are first distributed to different subcarriers and then to higher- or lower-significant bits of the constellation used for subcarrier modulation. Long sequences of defective bits can thus be avoided which significantly improves the faculties of the Viterbi decoder in the receiver for a correction.
The next stage performs the actual modulation of the individual OFDM carriers. Depending on the set data rate, the useful carriers are subjected to a uniform BPSK, QPSK, 16QAM or 64QAM modulation. This is done by first calculating the I and Q coefficients of each carrier. Gray coding is used to distribute the data bits to constellation points. All carriers from -26 to +26, except carriers -21, -7, 0, 7 and 21, are used for the transmission of user data. Carrier number 0 (directly at the center frequency later on) is not used and is always 0. The remaining 4 are BPSK-modulated pilots. The pilot carriers change their phase with each symbol. The phase variation is determined by the 127-bit PN sequence already defined as scrambling sequence.
The actual OFDM modulation is performed by inverse discrete Fourier transform (IFFT) in the next step. A 64-point IFFT is carried out with the I and Q coefficients of the subcarriers obtained before. To ensure sufficient spacing of aliasing products, only 52 of the 64 possible carriers are used. The result is a discrete complex time signal in the baseband with modulated OFDM carriers. A guard field which corresponds to a periodic continuation of the same symbol is then appended before each OFDM symbol. Multipath propagation can thus be easily compensated in the receiver.
Aliasing products are suppressed by oversampling, converting the discrete digital signal to an analog signal and subsequent filtering. In the last step, the baseband signal is modulated onto the selected RF carrier and the complete signal is sent to the receiver via the air interface.

17.2 Generating 802.11a Signals with WinIQSIM

To generate a 802.11a signal, the IEEE 802.11a WLAN system must be selected first.



System Selection

System

○ Single Carrier
○ Multi Carrier
○ Multi Carrier Mixed Signal
○ 3GPP W-CDMA FDD
○ 3GPP W-CDMA TDD
○ TD-SCDMA
○ IS-95
○ CDMA2000
○ 1xEV-DO
● IEEE 802.11a WLAN
○ IEEE 802.11b WLAN
○ Import

Fig. 17-3: System selection 802.11a

This system selection is accessible from the File New... or System! menu.
The differences between the two methods are described in sections 5.22.1 and 5.23.

The 802.11a block diagram is based on that of the single-carrier system. Only the modulation block has been replaced by the IEEE 802.11a configuration block.

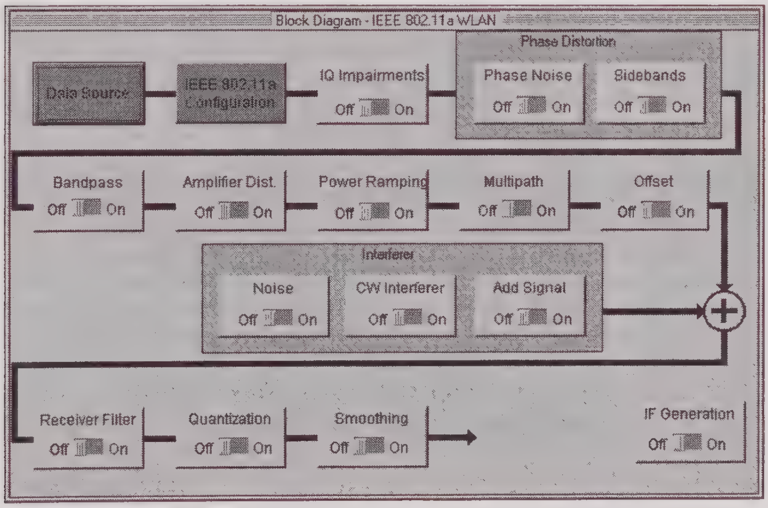


Fig. 17-4: Block diagram of 802.11a system

The data source block corresponds to that of the single-carrier system. For description see section 5.6.

17.2.1 Status Line

The main parameters of the 802.11a system are displayed in the status line below the toolbar of the main panel. The set parameters can thus be seen at a glance.

The status line contains symbols for the different parameters; below the symbols the current parameter values are displayed. The figure below shows the status line of the 802.11a system with the parameters assigned to the symbols.

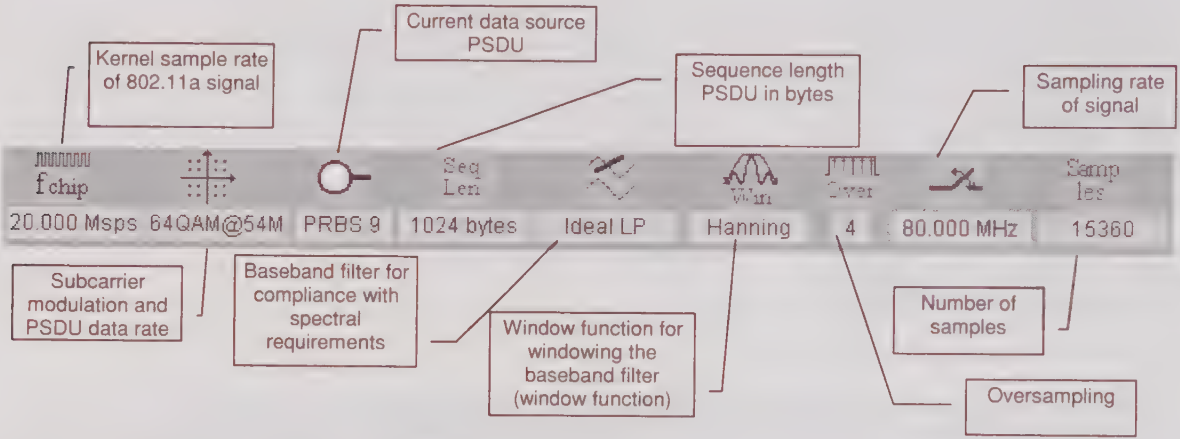

Current data source PSDU
Kernel sample rate of 802.11a signal
Sequence length PSDU in bytes
Sampling rate of signal
fchip
Seq Len
Win
Over
Samp les
20.000 Msps
64QAM@54M
PRBS 9
1024 bytes
Ideal LP
Hanning
4
80.000 MHz
15360
Subcarrier modulation and PSDU data rate
Baseband filter for compliance with spectral requirements
Window function for windowing the baseband filter (window function)
Number of samples
Oversampling

Fig. 17-5: Status line for 802.11a system

17.2.2 IEEE 802.11a Configuration Panel

All important control elements of the 802.11a system are on this panel.
802.11a signals can be generated in two different modes. The **framed mode** is the standard operating mode which is also used in the real system. Data packets with the frame structure defined by the standard are generated. The **unframed mode** is offered in addition. In this mode, a non-packet-oriented signal without a frame structure is generated with the modulations and data rates defined by 802.11a. This mode can be used for simple tests for which only modulation and spectrum of the test signal are of interest.

Simulation mode framed / unframed:
The current simulation mode is displayed in the upper part of the panel. The following is displayed in the framed mode:

Fig. 17-6: Display of simulation mode

Signals representing a sequence of frames (PLCP protocol data units, referred to as PPDUs) and separated by a so-called idle time can be configured in the framed mode. The user data is continued in the consecutive frames, i.e. it is not repeated in each frame. Both the duration of the idle time and the number of frames to be sent can be user-selected.

In the unframed mode, a non-packet-oriented signal without a frame structure is generated with the modulations and data rates defined by 802.11 a. This mode can be used for simple tests for which only modulation and spectrum of the test signal are of interest. No PLCP preamble and no signal field are generated in the unframed mode. The idle time is also omitted. The data field is identical to that of the framed mode and also contains the service and tail bits. The length limitation stipulated by the standard to the maximum PSDU block length of 2312 bytes in the framed mode does not apply.
Operation is the same as in the framed mode, but only a limited number of setting parameters is available.

Kernel Sample Rate Variation:
This parameter allows a variation of the kernel sample rate. WinIQSIM uses the 64-point IFFT recommended by the standard to generate the OFDM carriers. The time signal generated in this way has to be output with a sampling frequency of 20 MHz to comply with the stipulated timing parameters (such as subcarrier spacing, symbol duration etc.). The kernel sample rate can be changed e.g. to simulate frequency errors of the transmitter. All timing parameters of the OFDM are changed accordingly. A reset to the standard value of 20 MHz is possible with "Set to standard".
Note: The parameters "Idle Time" and "Transition Time" (time domain windowing) are always referenced to a standard value of 20 MHz. A variation of the kernel sample rate also modifies these parameters by the factor *20 MHz / kernel sample rate.*

Set to standard:
The "Kernel sample rate variation" is reset to the standard value of 20 MHz by means of this button. All other parameters remain unchanged.

Idle Time (based on standard sample rate):
In this field the idle time between successive packets (PPDUs) can be set in the framed mode. The idle time is specified in µs. Packets can also be transmitted consecutively with the idle time = 0. The idle time is always referenced to the standard kernel sample rate of 20 Mbps. Only at this sample rate does the idle period exactly correspond to the set period of time. Doubling the sample rate would halve the actual idle time.

Number of frames:
Here the number of frames to be generated is entered. The minimum frame number is 1, the maximum number is determined by the memory capacity of the AMIQ or of the ARB option B60 in the SMIQ. The total length of a frame in samples depends on the number of data symbols, the idle time and oversampling. The currently possible number of frames can be determined as a function of the AMIQ model used or the SMIQ-B60.
The length of a waveform in samples is calculated as follows. The number of OFDM symbols in the data section is determined first:

N_symbols = ceiling((16 + 8 x LENGTH + 6) / N_DBPS)

where LENGTH is the number of data bytes including MAC header and FCS, and N_DBPS the number of data bits per symbol (see table, right column). The additional 16 and 6 bits – as given by the above formula – result from the service field and the at least 6 tail bits.

Table 17-2: Signal parameters depending on data rate

Data rate (Mbits/s)	Modulation	Code rate (R)	Coded bits per subcarrier (N_{BPSC})	Coded bits per OFDM symbol (N_{CBPS})	Data bits per OFDM symbol (N_{DBPS})
6	BPSK	1/2	1	48	24
9	BPSK	3/4	1	48	36
12	QPSK	1/2	2	96	48
18	QPSK	3/4	2	96	72
24	16QAM	1/2	4	192	96
36	16QAM	3/4	4	192	144
48	64QAM	2/3	6	288	192
54	64QAM	3/4	6	288	216

If the number of data symbols is known, the number of samples in the framed mode is calculated as follows:

N_samples = ((N_symbols + 5) * 80 + idle time * 20) * oversampling

The additional 5 symbols are obtained from the preamble (16 µs) and the signal field. An OFDM symbol consists of 80 kernel samples. Since the idle time is always referenced to the standard sample rate of 20 MHz, 20 empty samples are generated per µs.
In the unframed mode, the preamble and the signal field are not transmitted. The number of samples is obtained by the following equation

N_samples = N_symbols * 80 * oversampling

The maximum possible signal length also depends on the ARB used. The SMIQB60 comprises 512 ksamples, the AMIQ03 4 Msamples and the AMIQ04 16 Msamples.

Example: Framed mode, idle time = 16 µs, data rate 54 Mbps, PSDU data length 2312 bytes, MAC header and FCS activated. The length of a frame is therefore 92 OFDM symbols.

Over-sampling factor	Maximum signal duration			Maximum number of frames		
	SMIQB60	AMIQ03	AMIQ04	SMIQB60	AMIQ03	AMIQ04
5	-	40.00 ms	160.00 ms	-	104	416
4	-	50.00 ms	200.00 ms	-	130	520
3	-	66.67 ms	266.67 ms	-	173	694
2	12.80 ms	100.00 ms	400.00 ms	33	260	1041

Since the SMIQB60 can be operated with a sample rate of max. 40 MHz, oversampling factors >2 are not possible. This is no drawback, however, as the internal interpolation filter performs additional oversampling in real time so that aliasing products are sufficiently attenuated. An oversampling factor of 2 is therefore excellent, a factor of 1 not recommend. Das Filtern der Wiederholspektren wäre damit nur schwer möglich, was die EMV der äußeren OFDM-Trägerlinien deutlich verschlechtert.Filtering out aliasing products would be extremely difficult in this case and considerably reduce the error vector magnitude (EVM) of the outer OFDM carrier lines.

PSDU Bit Rate:
The bit rate of the PSDU data section is selectable between 6 and 54 Mbps. All data rates defined by the standard are supported. The selection of the PSDU bit rate automatically determines the code rate of the convolutional coder and the subcarrier modulation of the OFDM as shown in Table 17-2: Signal parameters depending on data rate . All other parameters of the OFDM are standard-conformal to [2], section 17.3.2.3.

PSDU Modulation:
The modulation mode used on the OFDM subcarriers is indicated. The setting is performed by the PSDU bit rate.

Data Length:
In the framed mode, data field lengths of up to 2312 bytes are possible. This corresponds to the maximum data length defined by 802.11 MAC. The unframed mode offers a data length of up to 100000 bytes. When the currently generated data section of the PSDU frame is activated, the MAC headers (up to 30) and the (4) FCS bytes are added. If the data field length is changed, WinIQSIM calculates the number of OFDM data symbols as a function of the set PSDU bit rate and displays it in the field "No of Data Symbols". Data is always rounded up to complete symbols. Free data bits in the last symbol, the so-called pad bits, are filled with 0.

No of Data Symbols:
The parameter "No of data symbols" can be used as an alternative to "Data length". When a value is entered, "Data length" is set to the maximum number of data bytes possible for this setting.

Scrambler Active:
Activates or deactivates the scrambler in line with [2], 17.3.5.4.

Scrambler Init Mode:
The initialization value of the scrambler can either be selected at random or set to a fixed value. In the "Random" mode, each frame has a different random initialization value. This value is also different in case of successive recalculations with the same setting parameters so that different signals are generated for each calculation. If this is to be avoided, the "Scrambler Init Mode" can be set to "User" and the initialization value of the scrambler can be entered in the "Scrambler Init" field. This value is then be identical in each generated frame.

Scrambler Init:
Initialization value of scrambler in the scrambler init mode "User". Enter in hexadecimal format.

Interleaver Active:
Activates or deactivates the interleaver in line with [2], 17.3.5.6

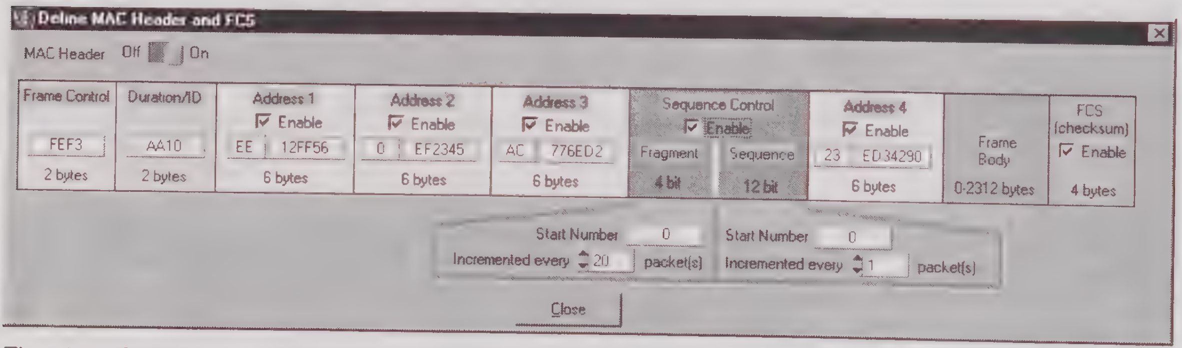
Time Domain Windowing Active:
Time domain windowing to [2], 17.3.2.4 can here be activated. Time domain windowing is a method to influence the spectral characteristics of the signal, which is not stipulated by the standard. However, it does not replace oversampling and subsequent signal filtering.

Transition Time T_{TR}:
Defines the overlap range of two OFDM symbols when time domain windowing is active. At a setting of 100 ns, one sample overlaps.

Service Field:
This parameter allows to define the content of the service field of each frame. The standard specifies a default value of 0. Other values can be entered in hexadecimal form for test purposes or future extensions.

17.2.2.1 Configure MAC Header and FCS

In the real IEEE 802.11a system, a so-called MAC (medium access control) header is transmitted in the PSDU prior to the actual data section. This header comprises control information of the MAC layer. It is also possible to protect the PSDU by a checksum. These two functions can be controlled in the "Configure MAC Header and FCS" panel.



MAC Header Off ▨ On

Frame Control	Duration/ID	Address 1	Address 2	Address 3	Sequence Control		Address 4	Frame Body	FCS (checksum)
		☑ Enable	☑ Enable	☑ Enable	☑ Enable		☑ Enable		☑ Enable
FEF3	AA10	EE 12FF56	0 EF2345	AC 776ED2	Fragment	Sequence	23 ED34290		
2 bytes	2 bytes	6 bytes	6 bytes	6 bytes	4 bit	12 bit	6 bytes	0-2312 bytes	4 bytes

Start Number 0
Incremented every 20 packet(s)

Start Number 0
Incremented every 1 packet(s)

Fig. 17-7: Configure MAC header and FCS panel

MAC Header state:
It can be selected whether the PSDU should contain a MAC header or not.
If the MAC header is On, all MAC header fields are enabled for operation.

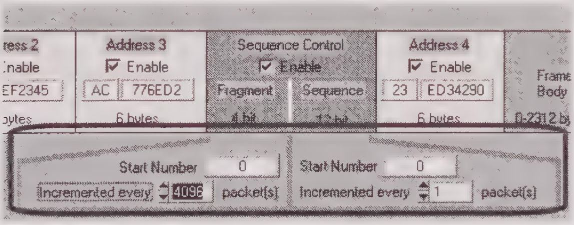
The individual fields of the MAC header are briefly described in the following. For details see [2], section 7.1, MAC Frame Formats.
All values of the MAC fields are entered in hexadecimal form with the LSB on the right. In the data stream, the values are output standard-conformal with the LSB coming first.

Frame Control:
The Frame control field has a length of 2 bytes (16 bits) and is used to define the protocol version, the frame type and its function, etc.

Duration/ID:
Depending on the frame type, the 2-byte field Duration/ID is used to transmit the association identity of the station transmitting the frame or it indicates the duration assigned to the frame type.

Address 1-4:
The MAC header may contain up to four address fields, but not all of them must be available. Each of the 4 address fields can be activated or deactivated. The fields are used for transmitting the basic service set identifier, the destination address, the source address, the receiver address and the transmitter address. Each address is 6 bytes (48 bit) long. The addresses can be entered in hexadecimal form in the two entry fields of each address field separated into the two most significant bytes (16 MSBs) and the 4 least significant bytes (32 LSBs).

Sequence Control:
The sequence control field has a length of 2 bytes and is divided in two parts, the fragment number (4 bits) and the sequence number (12 bits) field. A long user data stream to be transmitted is first split up into MSDUs (MAC service data units) which can either be transmitted as PSDU frames or further divided into fragments. The sequence number and the fragment number are then used to number the individual subpackets of the user data stream to be transmitted. Thus, all PSDUs are assigned a consecutive number. This allows the receiver to arrange the data packets in the correct order, to determine whether an incorrectly transmitted packet was retransmitted and to find out whether packets are missing.
If the receiver can detect a packet without an error and does not request a retransmission, the sequence number is incremented by 1 for each packet (the field is reset to 0 at the latest after a count of 4095). The fragment number field is incremented by 1 when another fragment of the current MPDU is transmitted. The start count for the transmission (normally 0) and the number of packets required to increment the corresponding counter can be defined for both numbers. This is done with the parameters **Start Number** and **Incremented every ... packet(s)**.
Example:
An error-free transmission of 50 packets (no packet retransmission) is to be simulated. The sequence number should be incremented by 1 for each packet. Since no packet is fragmented, the fragment counter can always remain at 0. In this case the following values have to be set:



Address 3 ☑ Enable AC 776ED2 6 bytes

Address 4 ☑ Enable 23 ED34290 6 bytes

Sequence Control ☑ Enable

Start Number 0
Incremented every 4096 packet(s)

Start Number 0
Incremented every 1 packet(s)

Fig. 17-8: Example for setting the sequence control

If you want to simulated that some packets are received incorrectly or if the response of the receiver should be tested when the same packet arrives several times, the number of packets required to increment the sequence number can be set to 2, for example. Each packet will then automatically be sent twice (with identical data).

FCS (check sum):
The standard defines a 32-bit (4-byte) check sum to protect the MAC header and the user data (frame body). The calculation of the check sum - also called frame check sequence (FCS) can be activated or deactivated.

Data Source:
The data source, from which the user data for the signal is derived, can be set in the Data Source block of the diagram in the same way as for the single-carrier system. For further information on the data source panel refer to section 5.6.
Note that WinIQSIM data supplied via files is always processed in the given order. To conform with the 802.11a standard, data has to be provided in the LSB-left notation.

17.2.2.2 Filtering

After the generation, the 802.11a raw signal is discrete in time and available at a kernel sample rate of 20 MHz. This signal must then be oversampled to allow suppression of adjacent spectra. An oversampling factor of 2 should at least be selected. After oversampling, the signal has to be filtered to comply with the specified transmit spectrum mask ([2], 17.3.9.2).

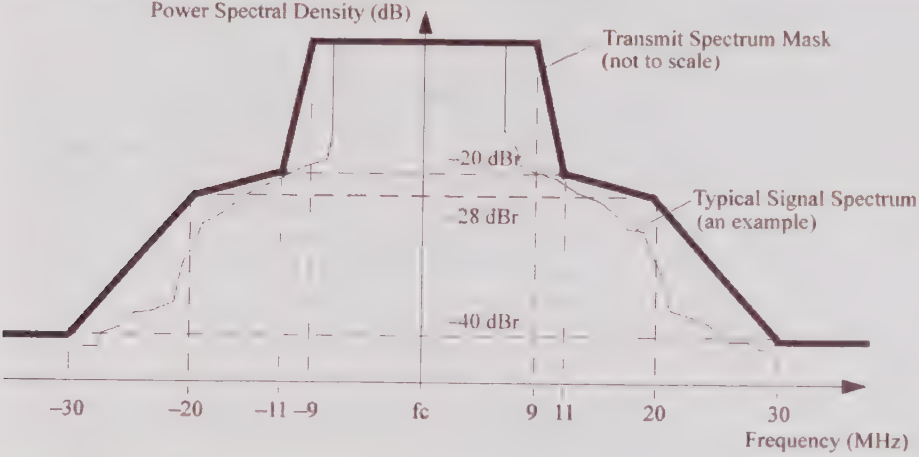
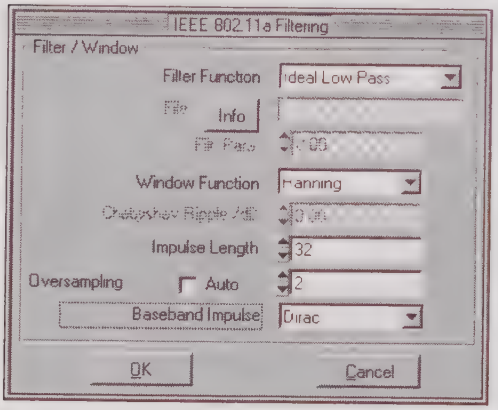


Fig. 17-9: Transmit spectrum mask

The standard does not specify a filter. We recommend to use an ideal lowpass filter with Hanning window as shown in the Filtering panel below.



Filter Function: Ideal Low Pass

Window Function: Hanning

Impulse Length: 32

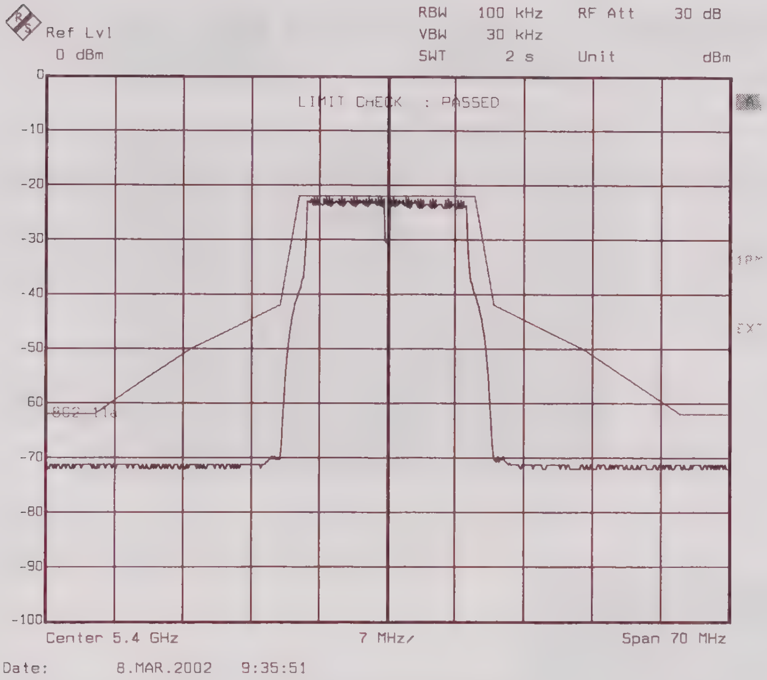
Oversampling ☐ Auto: 2

Baseband Impulse: Dirac

Fig. 17-10: IEEE 802.11a Filtering

For a description of the individual parameters see section 5.8, Modulation Settings Panel.

The diagram below shows the spectrum of a 802.11a signal generated this way by SMIQ and analyzed by FSIQ. The red lines indicate the transmit spectrum mask to be met by the signal.



Ref Lvl 0 dBm
RBW 100 kHz RF Att 30 dB
VBW 30 kHz
SWT 2 s Unit dBm

LIMIT CHECK : PASSED

Center 5.4 GHz 7 MHz/ Span 70 MHz

Date: 8.MAR.2002 9:35:51

Fig. 17-11: IEEE 802.11a signal measured with FSIQ

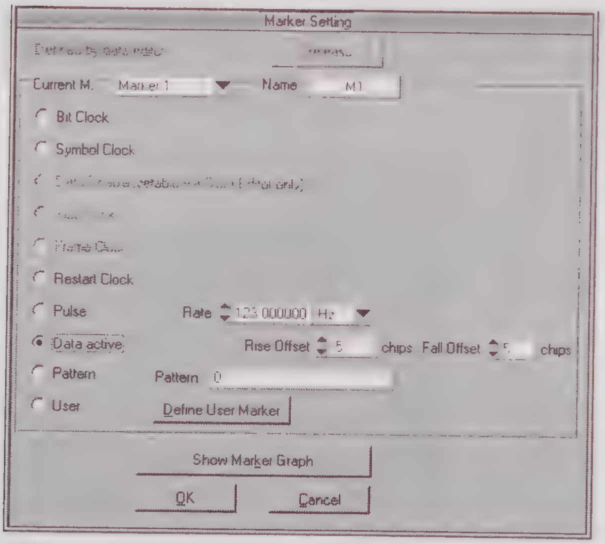
17.3 Further Information on Generation of 802.11a Signals

17.3.1 Increase of Dynamic Range Between Packet and Idle Range

To obtain a high ON/OFF power ratio, i.e. a wide dynamic range between the active and inactive signal parts (packet and idle state), the dynamic range of the baseband is usually not sufficient. The RF signal should additionally be switched off in the inactive signal ranges.
This is achieved by a combination of WinIQSIM, AMIQ and SMIQ.

With WinIQSIM, an AMIQ marker output can be configured so that it marks the range of active signal components synchronously to the I/Q signal. This marker signal can be used to control the pulse modulator of the SMIQ and thus to increase the dynamic range.
This method is described in detail in the following:

1. First define the **Data active** marker in the marker panel (AMIQ ⇨ Marker Setting...)



Current M. Marker 1
Name M1

○ Bit Clock
○ Symbol Clock
○ Restart Clock
○ Pulse Rate 123.000000 Hz
● Data active Rise Offset 5 chips Fall Offset 5 chips
○ Pattern Pattern 0
○ User Define User Marker

Fig. 17-12: Marker Setting panel 3GPP TDD

The data active marker can only be generated for marker channel 1 of the AMIQ.

To optimally adapt the marker signal to requirements, the rising (**rise offset**) and falling edge (**fall offset**) of the marker signal can be shifted independently of each other. This is illustrated in the diagram below.

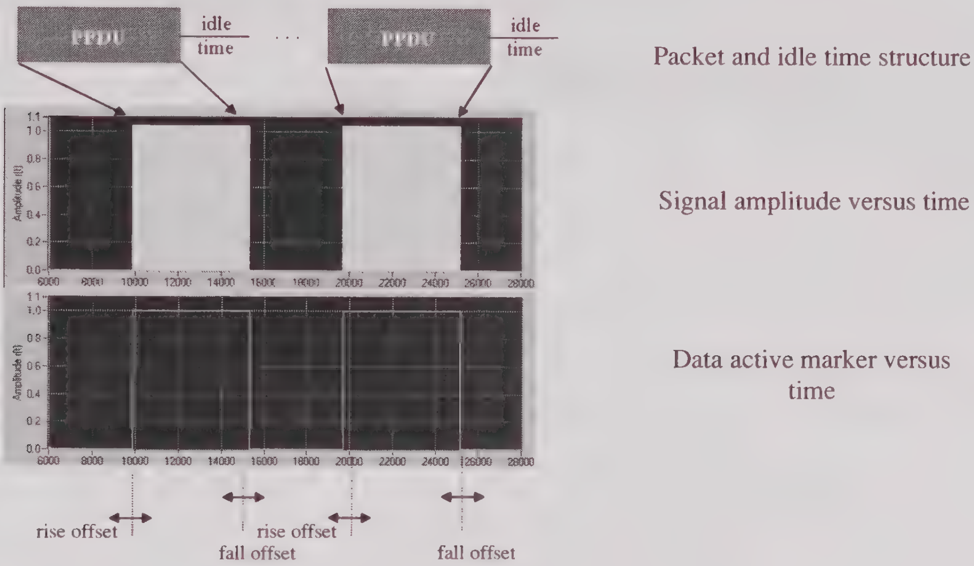


Fig. 17-13: Generation of data active marker

2. Transmit the I/Q signal to the AMIQ (AMIQ ⇨ Transmission) and activate marker channel 1 in the AMIQ ⇨ Remote Control and BERT... menu.
3. Connect BNC cables between the following input and output connectors of the AMIQ and SMIQ:
   - Connect I and Q outputs of the AMIQ to the I and Q inputs on the SMIQ front panel.

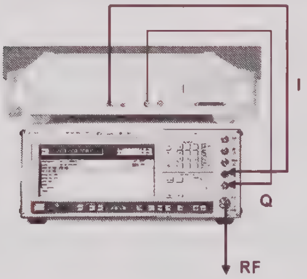


Fig. 17-14: Connection of I/Q inputs and outputs of AMIQ and SMIQ

   - Connect the marker 1 output on rear panel of the AMIQ to the pulse input connector on the rear panel of the SMIQ.

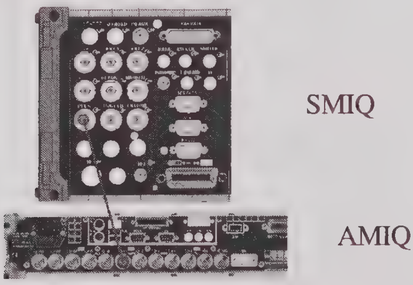


Fig. 17-15: Connection of marker 1 output of AMIQ to the PULS input of SMIQ

4. Activate vector modulation in the SMIQ and also external pulse modulation in the ANALOG MOD ⇨ PULSE menu.

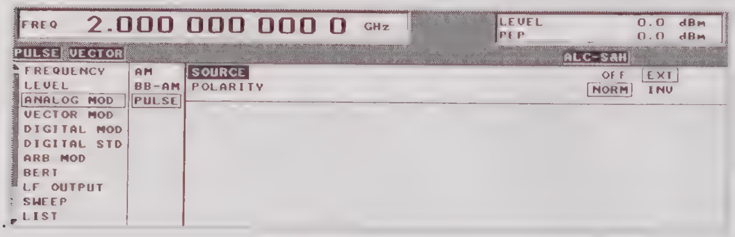
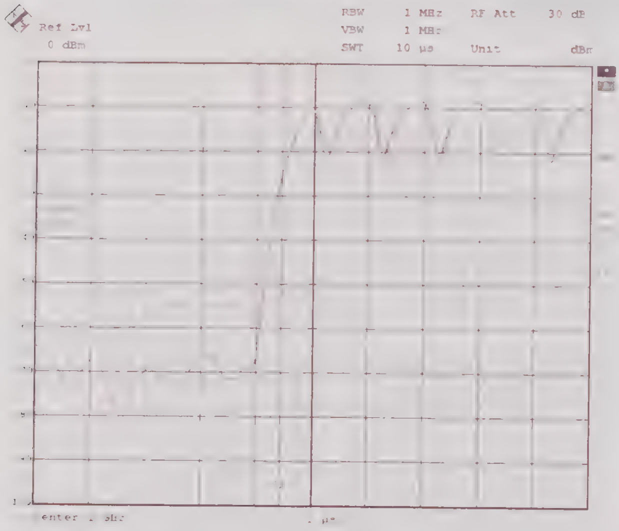


Fig. 17-16: Activating external pulse modulation in the SMIQ

5. Optimize the ON/OFF ratio by shifting the edges (rise and fall offset) in the marker panel.

Note: *After changing the offsets the signal has to be transmitted again to the AMIQ.*



Date: 30.AUG.2001 09:24:40

Fig. 17-17: Change from idle time to active packet with (light blue trace) and without (yellow trace) pulse modulation.

The increase of the dynamic range by approx. 10 dB by means of a pulse modulator is clearly visible in the diagram above.

When optimizing the ON/OFF ratio the following should be observed:

- The pulse modulator should not switch in the range of high-edge levels. Hard switching-on or switching-off would cause high signal amplitude variations in the time domain, and thus unwanted spurious in the spectrum. For this reason, the rise offset should be in the range of half the negative pulse length (see Filtering panel) and the fall offset in the range of half the pulse length. Here the levels of the I/Q signal are very low already.

  Impulse Length 32

- The pulse modulator must not switch too late either in order not to deviate from the power time template stipulated by the standard.

A compromise has to be found between these two requirements to ensure both a pure spectrum and conformance with the power time template.